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Aggregate Resources Inventory Paper 7

AGGREGATE RESOURCES INVENTORY OF MANVERS TOWNSHIP VICTORIA COUNTY SOUTHERN ONTARIO

by

Staff of the Engineering and Terrain Geology Section

Ontario Geological Survey

1980

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ABSTRACT

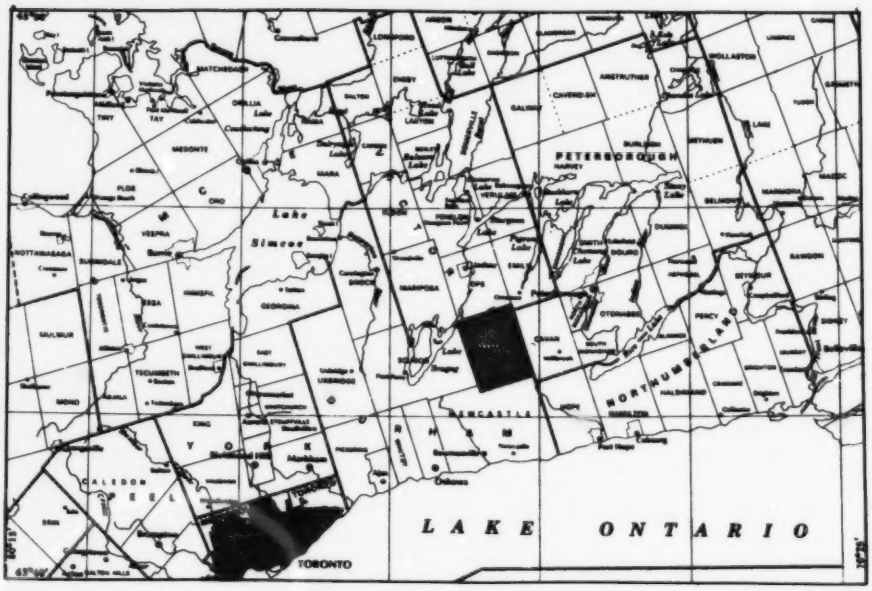


Figure 1 - Key Map Showing Location of Manvers Township. Scale 1: 1 800 000.

An inventory and evaluation of aggregate resources, which include crushed stone derived from bedrock as well as natural sand and gravel were completed for Manvers Township in 1979. This is part of the Aggregate Resources Inventory Program for townships and municipalities designated under The Pits and Quarries Control Act, 1971. The aggregate resources in the township have been assessed according to standards developed for the Program.

In Manvers Township, three areas containing significant amounts of sand and gravel have been selected for possible resource protection. Selected Sand and Gravel Resource Areas have an area of 5300 acres (2140 ha), exclusive of licenced areas. An estimated 4610 acres (1870 ha) are currently available for extraction, containing possible resources of 375 million tons (340 million tonnes). The parts of the Selected Areas which are presently available for extraction represent approximately 10 percent of the total area occupied by sand and gravel deposits in the township and 20 percent of the total resource tonnage.

Selected Sand and Gravel Resource Area 1, in south-central Manvers Township, constitutes the most important natural aggregate deposit and contains an estimated 345 million tons (313 million tonnes) of sand and gravel suitable for a wide range of road-building and construction aggregates. The quantity of crushable gravel may be low in some portions of the resource area.

Selected Resource Areas 2 and 3 are portions of an extensive esker-kame complex in the northeastern corner of the township. Twenty-nine million tons (26 million tonnes) of sand and gravel suitable for a wide range of aggregate products are available in these two areas.

Manvers Township has sand and gravel resources which are an important regional source of road-building and construction material. Care should be taken to ensure the continuing availability of these resources.

The poor physical properties of the bedrock (Lindsay Formation) underlying Manvers Township and the thick drift cover preclude the possible use of bedrock as a source of crushed stone.

Selected Resource Areas are not intended to be permanent, single land use units which must be incorporated in an official planning document. They represent areas in which a major resource is known to exist. Such resource areas may be reserved wholly or partially for extractive development and/or resource protection within the context of the official plan.

AGGREGATE RESOURCES INVENTORY OF MANVERS TOWNSHIP

BY
STAFF OF THE ENGINEERING
AND TERRAIN GEOLOGY SECTION

INTRODUCTION

Mineral aggregates, which include bedrock-derived crushed stone as well as naturally formed sand and gravel, constitute the major raw material in Ontario's road-building and construction industries. Very large amounts of these materials are used each year throughout the Province. For example, in 1976, the total tonnage of mineral aggregates extracted was greater than that of any other metallic or nonmetallic commodity mined in the Province (Ontario Ministry of Natural Resources 1977).

Although mineral aggregate deposits are plentiful in southern Ontario, they are fixed-location, nonrenewable resources which can be exploited only in those areas where they occur. Mineral aggregates are characterized by their high bulk and low unit value so that the economic value of a deposit is a function of its proximity to a market area as well as its quality and size. The potential for extractive development is usually greatest in urban fringe areas where land use competition is extreme. For these reasons the availability of adequate resources for future development is now being threatened in some areas.

Comprehensive planning and resource management strategies are required to make the best use of available resources, especially in those areas experiencing rapid development. Such strategies must be based on a sound knowledge of the total mineral aggregate resource base at both local and regional levels. The purpose of the Aggregate Resources Inventory is to provide the basic geological information required to include potential mineral aggregate resource areas in planning strategies and official plans. The reports should form the basis for discussion on those areas best suited for possible extraction. The aim is to assist decision-makers in protecting the public well-being by ensuring that adequate resources of mineral aggregate remain available for future use.

This report is a technical background document, based for the most part on geological information and interpretation. It has been designed as a component of the total planning process and should be used in conjunction with other planning considerations, to ensure the best use of a municipality's resources.

The report includes an assessment of sand, gravel and crushed bedrock. The most recent information available has been used to prepare the reports. As new information becomes available, revisions may be necessary.

PART I - INVENTORY METHODS

FIELD AND OFFICE METHODS

The methods used to prepare the report primarily involve the interpretation of published geological data such as bedrock and surficial geology maps and reports (see References). Wherever possible, field examination of potential resource areas was also undertaken to confirm interpretations made in the office. Field methods included the examination of natural and man-made exposures of granular material. Most observations were made at quarries and sand and gravel pits located from records held by the Ontario Ministry of Transportation and Communications, the Ontario Geological Survey, and by Regional and District Offices of the Ontario Ministry of Natural Resources. Observations made at pit sites included estimates of the total face height and the proportion of gravel- and sand-size fragments in the deposit. Observations were also made of the shape and lithology of the particles. These characteristics are important in estimating the quality and quantity of the aggregate. In areas of limited exposure, test pitting, soil probing and hand-augering techniques were used to assess subsurface materials. Air photos at various scales were used to determine the continuity of deposits, especially in areas of limited subsurface information.

In the office, the pit data were supplemented by information on file with the Engineering Materials Office of the Ontario Ministry of Transportation and Communications. Data contained in these files include field estimates of the depth, composition and "workability" of deposits as well as laboratory analyses of the physical properties and chemical suitability of the aggregate. Information concerning the development history of the pits and acceptable uses of the aggregate is also recorded. The location, size, and depth of extraction of pits licenced under The Pits and Quarries Control Act, 1971 were obtained from records held by Regional and District Offices of the Ontario Ministry of Natural Resources. The cooperation of the above named groups in the compilation of inventory data is gratefully acknowledged.

Water well records, held by the Ontario Ministry of the Environment, were used in some areas to corroborate thickness estimates, or to indicate the presence of buried granular material. These records were used only in conjunction with other evidence. Topographic maps of the National Topographic System, at a scale of 1:50 000, were used as a compilation base for the field and office data. The information was then transferred to a township base map, also at a scale of 1:50 000, prepared by the Cartography Section of the Lands and Waters Group, Ontario Ministry of Natural Resources, for presentation in the report.

RESOURCE TONNAGE CALCULATION TECHNIQUES

SAND AND GRAVEL RESOURCES

Once the interpretative boundaries of the aggregate units have been drawn, quantitative estimates of the possible resources available can be made. Generally, the volume of a deposit can be calculated if its areal extent and average thickness are known or can be estimated. The computation methods used are as follows: First, the area of the deposit, as outlined on the final base map, is calculated in acres. The thickness values used are an approximation of the deposit thickness, based on the face heights of pits developed in the deposit or on subsurface data such as water well logs. Original tonnage values can then be calculated by multiplying the volume of the deposit by 2500 (the density factor). This factor is approximately the number of tons in a one-foot thick layer of sand and gravel, one acre in extent, assuming an average density of 110 pounds per cubic foot.

Tonnage = Area x Thickness x Density Factor

Tonnage calculated in this manner must be considered only as an estimate. Furthermore, such tonnages represent amounts that existed prior to any extraction of material (i.e. original tonnage) (Table 1, Column 4).

The Selected Sand and Gravel Resource Areas in Table 3 represent only those parts of the deposit lying outside licenced areas (Column 2).

Two successive subtractions are made from the unlicenced area. Column 3 accounts for the number of acres unavailable due to the presence of permanent cultural features and their associated setback requirements. Column 4 accounts for those areas that have previously been extracted (e.g. wayside pits are included in this category). The remaining figure is the area of the deposit currently available for extraction (Column 5). The available area is then multiplied by the estimated deposit thickness and the density factor (Column 5 x Column 6 x 2500) to give an estimate of the sand and gravel tonnage presently available for extractive development and/or resource protection.

BEDROCK RESOURCES

The method used to calculate resources of bedrock-derived aggregate is much the same as that described above. The areal extent of favourable bedrock formations overlain by less than 50 feet (15 m) of unconsolidated overburden is determined from bedrock geology maps, drift thickness and bedrock topography maps and from the interpretation of water well records. The measured extent of such areas is then multiplied by the estimated workable thickness of the formation, based on stratigraphic analyses and on estimates of existing quarry faces in the unit. In some cases a standardized estimate of a workable thickness of 60 feet (18 m) is used. Volume estimates are then multiplied by 3600 (the estimated weight in tons of a one-foot thick section of dolostone, one acre in extent, assuming a bulk density of 165 pounds per cubic foot).

Resources of sandstone are calculated using a bulk density estimate of 146 pounds per cubic foot or approximately 3200 tons per acre. Shale resources are calculated on the basis of a bulk density estimate of 150 pounds per cubic foot.

UNITS AND DEFINITIONS

Although most of the measurements and other primary data available for resource tonnage calculations are given in Imperial units, Metric units have also been given in the text and on the tables which accompany the report. The Metric equivalent of the data is shown in brackets after or directly below the corresponding Imperial figures. Data are generally rounded off in accordance with the Ontario Metric Practice Guide (Metric Committee 1975).

The tonnage estimates made for sand and gravel as well as bedrock-derived aggregates are termed possible resources in accordance with terminology of the Ontario Resource Classification Scheme (Robertson 1975,p.7) and with the Association of Professional Engineers of Ontario (1976) (see Glossary, Appendix B).

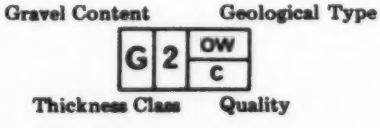
PART II - DATA PRESENTATION AND INTERPRETATION

Three maps, each portraying a different aspect of the aggregate resources in the municipality, accompany the report. Map 1, "Distribution of Sand and Gravel Deposits", gives a comprehensive inventory of the sand and gravel resources in the report area. Map 2, "Selected Sand and Gravel Resource Areas", shows those deposits which are considered to represent the largest and/or highest quality resources in the area. Map 3, "Bedrock Resources", shows the distribution of bedrock formations, the distribution of overlying unconsolidated sediments, and identifies the Selected Bedrock Resource Areas.

MAP 1: DISTRIBUTION OF SAND AND GRAVEL DEPOSITS

Map 1 is derived directly from the existing surficial geology maps of the area or from air photo interpretation where surficial mapping is incomplete. It shows the extent of sand and gravel deposits within the study area and serves as a base for the calculation of the total sand and gravel resources.

Map 1 presents a summary of all available information related to the quantity and quality of aggregate contained in all the known aggregate deposits in the study area. Much of this information is contained in the symbol which identifies each deposit. The Deposit Symbol is similar to those used in soil mapping and land classification systems commonly in use in North America. The components of the symbol indicate the gravel content, thickness of material, origin (type), and quality limitations for a given deposit. These components are illustrated by the following example:



This symbol identifies an outwash deposit 10 to 20 feet (3 to 6 m) thick containing more than 35 percent gravel. Excess fines may limit uses of the aggregate in the deposit.

The "gravel content" and "thickness class" are basic criteria for distinguishing different deposits. The "gravel content" symbol is an upper case "S" or "G". The "S" indicates that the deposit is generally "sandy" and that gravel-sized aggregate makes up less than 35 percent of the whole deposit. "G" indicates that the aggregate probably contains more than 35 percent gravel. If no information is available, the letters are omitted.

The "thickness class" indicates a depth range which is related to the potential resource tonnage for each deposit. Four thickness class divisions have been established as shown in the legend for Map 1.

Two smaller sets of letters, divided from each other by a horizontal line, follow the thickness class number. The upper series of letters identify the geologic deposit type (the types are summarized with respect to their main geologic and extractive characteristics in Appendix C) and the lower series of letters identify the main quality limitations that may be present in the deposit as discussed in the next section.

The other information presented on Map 1 is designed to give an indication of the present level of extractive activity in the study area. Those areas which are licenced for extraction under The Pits and Quarries Control Act, 1971 are shown by a solid outline and identified by a number which refers to the pit descriptions in Table 2. Each description notes the owner, location and licenced acreage of the pit, as well as the estimated face height and percentage gravel. A number of unlicenced pits are also identified and numbered on Map 1 and described in Table 2.

MAP 2: SELECTED SAND AND GRAVEL RESOURCE AREAS

Map 2 is an interpretative map derived from an evaluation of the deposits shown on Map 1. The deposits identified on Map 2 are those which are considered to be important in ensuring an adequate resource base for the future.

All the selected sand and gravel resource areas are first delineated by geological boundaries and then classified into three levels of significance: primary, secondary, and tertiary. These areas are identified on Map 2 by different shading patterns.

Each area of primary significance is assessed as to its probable relative value as a resource in the municipality and is given a deposit number which denotes its ranking order. All such deposits are shown by a medium-grey tone on Map 2.

Selected Aggregate Resource Areas of primary significance are not permanent, single land use units which must be incorporated in an official planning document. They represent areas in which a major resource is known to exist. Such resource areas may be reserved wholly or partially for extractive development and/or resource protection within the context of the official plan.

Deposits of secondary significance are not ranked numerically in this report, but are indicated by a light grey tone on Map 2. Such deposits are believed to contain significant amounts of sand and gravel. Although deposits of secondary significance are not considered to be the "best" resource areas in a municipality, they may contain large quantities of sand and gravel and should be considered an integral component of the aggregate supply of the municipality.

Areas of tertiary significance are indicated on the map by a dashed line but have no grey tone. They are neither rated nor considered to be important resource areas because of their low available resources, or because of possible difficulties in extraction. Such areas may be useful for local needs but are unlikely to support large-scale development.

The process by which deposits are evaluated and selected involves the consideration of two sets of criteria. The main selection criteria are site specific, related to the characteristics of individual deposits. Factors such as deposit size, aggregate quality, and deposit location and setting are considered in the selection of those deposits best suited for extractive development. A second set of criteria involves the assessment of local aggregate resources in relation to the quality, quantity, and distribution of resources in the region in which the municipality is located. The intent of such a process of evaluation is to ensure the continuing availability of sufficient resources to meet possible future demands.

SITE SPECIFIC CRITERIA

DEPOSIT SIZE

Ideally, selected deposits should contain available sand and gravel resources large enough to support a commercial pit operation using a stationary or portable processing plant. In practice, much smaller deposits may be of significant value depending on the overall reserves in the rest of the municipality. Generally, deposits in Class 1, i.e. those thicker than 20 feet (6m) and containing more than 35 percent crushable gravel are considered to be most favourable for commercial development. Thinner deposits may be valuable in municipalities with low total resources.

AGGREGATE QUALITY

The limitations of natural aggregates for various uses result from variations in the lithology of the particles composing the deposit, and from variations in the size distribution of these particles.

Four indicators of the quality of aggregate may be included in the symbol for each deposit on Map 1. They are: gravel content (G or S), fines (C), oversize (O) and lithology (L).

Three of the indicators deal with grain size distribution. The "gravel content", (G or S), indicates the suitability of aggregate for various uses. Deposits containing more than 35 percent crushable gravel are considered to be favourable extractive sites, since this content is the minimum from which crushed products can be economically produced.

Excess "fines" or high silt and clay content may severely limit the potential use of an aggregate. Fines content in excess of 10 percent may impede drainage in road sub-base aggregate and render it more susceptible to the effects of frost action. In asphalt aggregate, excess fines hinder the bonding of particles. Deposits known to have a high fines content are indicated by a "C" in the quality portion of the Deposit Symbol.

Deposits containing more than 20 percent "oversize" particles (those greater than 4 inches (10 cm) in diameter) may also have use limitations. The oversize component is unacceptable for all concrete aggregate and for road-building

aggregate, so must be either crushed or removed during processing. Deposits known to have an appreciable oversize component are indicated by an "O" in the quality portion of the Deposit Symbol.

The other indicator of the quality of an aggregate is "lithology". Just as the unique physical and chemical properties of bedrock formations determine their value for use as crushed rock, so do various lithologies of particles in a sand and gravel deposit determine its suitability for various uses. The presence of objectionable lithologies such as chert, siltstone, and shale, even in relatively small amounts, can result in a reduction in the quality of an aggregate, especially for high-quality uses. Deposits known to contain objectionable lithologies are indicated by an "L" in the quality component of the Deposit Symbol.

If the Deposit Symbol indicates either "C", "O" or "L" or any combination, the quality of the deposit is considered to be reduced for some uses of the aggregate. No attempt has been made to quantify the degree of limitation imposed. Assessment of the four indicators is made from published data, from data contained in files of the Ontario Ministry of Transportation and Communications and the Engineering and Terrain Geology Section of the Ontario Geological Survey, and from field observations. The Engineering Materials Office of the Ontario Ministry of Transportation and Communications has recently compiled a detailed assessment of aggregate suitability for selected areas in southern Ontario. This material has been consulted extensively in preparation of the inventory reports.

LOCATION AND SETTING

The location and setting of a resource area has a direct influence on its value for possible extraction. The evaluation of a deposit's setting is made on the basis of those natural and man-made features which may limit or prohibit extractive development.

First, the physical context of the deposit is considered. Deposits with some physical constraint on extractive development, such as thick overburden or high water table, are less valuable resource areas because of the difficulties involved in resource recovery. Second, permanent man-made features, such as roads, railways, powerlines, and housing developments, which are built on a deposit, may prohibit its extraction. The constraining effect of legally required setbacks surrounding such features is included in the evaluation. A quantitative assessment of these constraints can be made by measurement of their areal extent directly from the topographic maps. The area rendered unavailable by these features is shown for each resource area in Table 3.

The assessment of sand and gravel deposits and bedrock resource areas with respect to local land use and to private land ownership is an important component of the general evaluation process. These aspects of the evaluation process are not considered further in this report but readers are encouraged to discuss them with personnel of the Ontario Ministry of Natural Resources' District Office.

REGIONAL CONSIDERATIONS

In selecting sufficient areas for resource development, it is important to assess both the local and the regional resource base, and to forecast future production and demand patterns.

Some appreciation of future aggregate requirements in an area may be gained by assessing its present production levels and by forecasting future production trends. Such an approach is based on the assumptions that production levels in an area closely reflect the demand and that the present production "market share" of an area will remain at roughly the same level.

The aggregate resources in the region surrounding a municipality should be assessed in order to properly evaluate specific resource areas and to adopt optimum resource management plans. For example, a municipality that has large resources in comparison to its surrounding region constitutes a regionally significant resource area. Municipalities with high resources in proximity to large demand centres, such as metropolitan areas, are special cases.

Although an appreciation of the regional context is required to develop comprehensive resource management techniques, such detailed evaluation is beyond the scope of this report. The selection of resource areas made in this study is based primarily on geological data

or on considerations outlined in preceding sections.

MAP 3: BEDROCK RESOURCES

Map 3 is an interpretative map derived from bedrock geology, bedrock topography, drift thickness maps, water well data from the Ontario Ministry of the Environment, oil and gas well data from the Petroleum Resources Section (Ontario Ministry of Natural Resources), and from geotechnical well data from various sources. Map 3 is based on concepts similar to those outlined for Maps 1 and 2, but displays both the inventory and evaluation on the one map.

The geological boundaries of the labelled bedrock units are shown by a dashed line. Isolated outcrops are indicated by an "X". Three sets of contour lines delineate areas of less than 3 feet (1 m) of drift, areas of 3 to 25 feet (1 to 8 m) of drift, and areas of 25 to 50 feet (8 to 15 m) of drift. The extent of the areas of thin drift are shown by three tones. The darkest tone indicates areas where bedrock outcrops or is within 3 feet (1 m) of the ground surface. These areas constitute potential resource areas of primary significance due to their easy access. The medium tone indicates areas where drift cover is up to 25 feet (8 m) thick. Quarrying is possible in this depth of overburden and these also represent potential resource areas. The lightest tone indicates bedrock areas overlain by 25 to 50 feet (8 to 15 m) of overburden. These latter areas constitute resources which have extractive value only in specific circumstances. Outside of these delineated areas the bedrock can be assumed to be covered by more than 50 feet (15 m) of overburden, a depth generally considered to be too great to allow economic extraction (unless part of the overburden is composed of economically attractive sand and gravel deposits).

Other inventory information presented on Map 3 is designed to give an indication of the present level of extractive activity in the municipality. Those areas which are licenced for extraction under The Pits and Quarries Control Act, 1971 are shown by a solid outline and identified by a number which refers to the quarry descriptions in Table 5. Each description notes the owner, location, and licenced acreage of the quarry and an estimate of face height. Unlicenced quarries are also identified and numbered on Map 3 and described in Table 5. One additional symbol appears on the map: an open dot indicates the location of a selected well which penetrates bedrock. The overburden thickness is shown in feet beside the open dot.

SELECTION CRITERIA

Criteria equivalent to those used for sand and gravel deposits are used to select bedrock areas most favourable for extractive development.

The evaluation of bedrock resources is made primarily on the basis of performance and suitability data established by laboratory testing at the Ontario Ministry of Transportation and Communications. The main characteristics and uses of the bedrock formations found in southern Ontario are summarized in Appendix D.

Deposit "size" is related directly to the areal extent of thin drift cover overlying favourable bedrock formations of sufficient thickness to support quarry operations. Since vertical and lateral variations in bedrock units are much more gradual than in sand and gravel deposits, the quality and quantity of the resource is usually consistent over large areas.

Quality of the aggregate derived from specific bedrock units is established by the performance standards previously mentioned. Location and setting criteria and regional considerations are identical to those for sand and gravel deposits.

SELECTED RESOURCE AREAS

Selection of bedrock resource areas has been restricted to a single level of significance. Three factors support this approach. Quality and quantity variations are gradual. The areal extent of a given quarry operation is much smaller than that of a sand and gravel pit producing an equivalent tonnage of material. Since crushed bedrock has a higher unit value than sand and gravel, longer haul distances can be considered. These factors allow the identification of alternative sites having similar development potential. The wider range of possible resource areas allows greater flexibility in locating quarry operations away from areas of intensive land use competition. The Selected Areas are shown on Map 3 by a line pattern and the calculated available tonnages are given in Table 6.

Selected Bedrock Resource Areas shown on Map 3 are not permanent, single land use units which must be incorporated in an official planning document. They represent areas in which a major bedrock resource is known to exist. Such a resource area may be reserved wholly or partially for extractive development and/or resource protection within the context of the official plan.

PART III - ASSESSMENT OF AGGREGATE RESOURCES IN MANVERS TOWNSHIP

LOCATION AND POPULATION

Manvers Township occupies an area of 73,083 acres (29 590 ha) in southern Victoria County, just east of Lake Scugog. The township is shown on portions of the Lindsay (31D/7) and Scugog (31D/2) map sheets of the National Topographic System at a scale of 1:50 000. Originally, Manvers Township formed part of the County of Durham, but became part of Victoria County during the restructuring process which formed the Regional Municipality of Durham in 1973.

There are no large population centres in the township. Port Perry to the west, Peterborough to the east, and Lindsay to the north are located a considerable distance away. Two local trade and retail centres, Pontypool and Bethany, are located near the southern and eastern boundaries, respectively.

The total population of Manvers Township was 3323 in 1978 (Ontario Ministry of Intergovernmental Affairs 1979, p.76). Figures from previous years indicate that the population has increased significantly. Much of this increase has resulted from an influx of rural-residential and seasonal-recreational inhabitants, drawn by the area's scenic value and recreational potential.

Population projections made by the Regional Planning Branch of the Ontario Ministry of Treasury, Economics and Intergovernmental Affairs (1976, p.135) indicate a population increase of 10 to 20 percent is probable by the year 2000. Such a population increase may necessitate increased production of sand and gravel products.

Road access in the township is good. The area is served by a grid of gravel-surfaced township and county roads. Paved King's Highway No. 35 runs north-south through the centre of the township, and No. 115 cuts across the southeast corner. Both highways join together just south of the southern boundary, and connect with King's Highway No. 401. These roads serve as a convenient haul route for the transportation of aggregates to the south. Proctor and Redfern Ltd. (1974, plate 8-13) indicate that sand and gravel from Manvers Township is moved south to supply demand along Highway No. 401 as far west as Oshawa and Ajax. A relatively large proportion of the aggregate reaches the Metropolitan Toronto market.

Railway lines of the Canadian Pacific Railway serve Pontypool and Bethany. The main line runs east-west through the southern part of the township and a northern branch line runs along the eastern boundary. Both lines are located near large aggregate resource areas and could provide convenient haulage routes.

PHYSIOGRAPHY AND SURFICIAL GEOLOGY

The physiography of Manvers Township and the distribution of unconsolidated sediments (which includes the sand and gravel deposits shown on Map 1) are the result of extensive glacial activity which took place in the latter part of the Wisconsinan Stage of the Pleistocene Epoch. This period of time, which lasted from approximately 23,000 to 12,500 years ago, was marked by the repeated advance and retreat of massive continental ice sheets.

Manvers Township was covered several times during the Wisconsinan by a lobe of the continental ice sheet, which advanced to the south, out of the lowlands of the Lake Simcoe basin. Concurrently, a second, semi-independent lobe, situated in the Lake Ontario basin, advanced to the north, to the southern boundary of Manvers Township (Gravenor 1957, p.40). During much of Late Wisconsinan time, the margins of the two ice lobes were confluent or in close proximity along an east-west trending zone at the southern edges of Rice Lake and Lake Scugog. Vast amounts of sediment-laden glacial meltwaters flowed off the ice margins during periodic climatic warming trends. The meltwaters deposited their sediment in the area between the ice margins, forming a broad hummocky ridge known as the Oak Ridges Moraine (Chapman and Putnam 1966, p.276).

The Oak Ridges Moraine is one of the largest

and most distinctive, glacially deposited physiographic features in Ontario. In Manvers Township, it is broad and irregular, occupying the southern third of the township, and extending north in two spurs to Bunker Hill and to Bethany. Much of the moraine in the centre of the township is masked by a younger till deposit (as in the area surrounding the hamlet of Manvers on Map 1).

The ridge has a maximum elevation in the township of more than 1200 feet (366 m) above sea level, and has local relief of up to 500 feet (152 m). The land surface on the moraine is typically hummocky and irregular. The internal structure of the moraine is complex, and although poorly exposed, several episodes of sand and gravel deposition are represented. Drilling data indicate the presence of as much as 400 feet (122 m) of stratified sand, gravel and silt. Surprisingly little clay or till is present (Gravenor 1957, p.27). Coarse granular material is at or near the ground surface in several places on the moraine. These areas are presently being worked at numerous licenced pits throughout the southern part of the township.

Following the formation of the Oak Ridges Moraine, the Lake Simcoe ice lobe retreated northward out of Manvers Township (Gravenor 1957, P.49). During this time, numerous glacial lakes covered much of the region.

A strong final advance by the Lake Simcoe lobe, again covered the township. The ice overrode the northern flank of the Oak Ridges Moraine, and advanced an unknown distance over its crest to the south (Gravenor 1957, p.40). This advance deposited a characteristic drumlinized till plain composed of stony sandy glacial till. The till forms an extensive physiographic unit known as the Peterborough Drumlin Field and covers much of south-central Ontario, including most of the northern two-thirds of Manvers Township (Chapman and Putnam 1966, p. 280). The till plain is characterized by numerous, drumlin land forms. The drumlins trend southwest, have relief of 50 to 100 feet (15 to 30 m) and lengths of 1500 to 6000 feet (457 to 1829 m). Stratified sand and gravel of uncertain origin is often incorporated in the drumlins, and this material has been extracted for local use throughout the region (Gravenor 1957, p.17). Further resources of similar material are small in Manvers Township and are not an important component of the area's overall resource base.

After its final advance, the margin of the Lake Simcoe lobe did not retreat to the north as it had on previous occasions. The main method of retreat was by "down-wasting". The ice sheet became stationary and melted-in-place or "stagnated". Ice stagnation deposits such as kames, eskers and crevasse fillings are common throughout the region, especially east of Peterborough. In Manvers Township, the main deposit of this type is a large esker-kame complex which extends from the southern tip of Pigeon Lake, through Franklin and Bethany, along the east side of Fleetwood Creek, in the northeast corner of the township. The esker has a relief of 50 to 75 feet (15 to 23 m) and consists of stratified sand and gravel deposited by meltwaters flowing south in a tunnel within the melting ice sheet. This deposit is an important aggregate resource area and is presently being worked at several licenced properties.

The stagnation of the Lake Simcoe lobe marked the end of glacial activity in Manvers Township. Postglacial erosional and depositional processes have been relatively minor in the area, except for limited stream and wind erosion on steep portions of the Oak Ridges Moraine.

EXTRACTIVE ACTIVITY

Manvers Township has been a traditional supplier of good-quality sand and gravel for local and regional markets. Sand and gravel extraction is a significant component of the township's employment and economic base, and will likely continue to be so in the near future.

Numerous sand and gravel pits have been operated in the township in the past. Most of the pits were used to meet local and private demand. In 1973, after designation of the township under The Pits and Quarries Control Act, 1971, many of the smaller operations were abandoned. At the time of writing, records of pit licence applications on file with Regional and District Offices of the Ontario Ministry of Natural Resources indicate that twenty properties are presently licenced for extraction.

The distribution of licenced and unlicenced sources indicates that a shift in areas of extraction has taken place. In the past, most of the extraction in the township was concentrated in stratified

sand and gravel kame deposits in a spur of the Oak Ridges Moraine which extends north towards Bethany. Many presently inactive pits are grouped just north of Pontypool, on the main body of the moraine. The aggregate in this area consists mainly of stratified sand with minor gravel. Presently licenced sources, which include a large number of new pits, are concentrated in the main ridge of the moraine, along the southern boundary of the township. The shift may have occurred as a result of the higher proportion of crushable gravel that may be found in this area.

The second greatest concentration of past and present extractive activity in the township is in the esker-kame complex which lies along the east bank of Fleetwood Creek in the northeast. These deposits are largely sand, although there are numerous areas of coarse gravel.

Pits throughout the township have a "moderate to high" use rating according to criteria established by the Ontario Ministry of Transportation and Communications (Deike 1978). Pits with moderate to high ratings are able to produce Granular Base Course "A", which must contain a large proportion of crushed fragments, and must have stone of sound lithology.

Presently licenced sand and gravel pits in Manvers Township are extensive. The total area occupied by licenced sources is 2892.9 acres (1170.8 ha). Using calculation techniques similar to those described in the Introduction, presently available sand and gravel resources in the licenced properties are estimated to be approximately 500 million tons (455 million tonnes).

Total annual production records for licenced sources have been kept by the Lindsay District Office of the Ontario Ministry of Natural Resources since designation of the township in 1973. The average annual production over the past five years is estimated to have been 1 million tons (1 million tonnes). Future production trends are likely to increase.

The above figures indicate that the presently licenced sand and gravel resources in Manvers Township may be sufficient to meet expected levels of production for a considerable number of years. Nevertheless, consideration should be given to providing planning controls for the areas which have been selected for possible resource protection.

SELECTED SAND AND GRAVEL RESOURCE AREAS

The sand and gravel deposits selected for possible resource protection in Manvers Township are shown on Map 2. The three areas of primary significance include two portions of the Oak Ridges Moraine, and the esker-kame complex in the northeast. The Selected Resource Areas correspond generally to areas identified in an earlier study of the aggregate resources of Manvers Township (Gwyn 1976).

The Selected Resource Areas occupy 5300 acres (2140 ha), exclusive of licenced areas. An estimated 4610 acres (1870 ha) are available for extractive development under present conditions. Possible resources of sand and gravel thus total approximately 375 million tons (340 million tonnes). The parts of the Selected Resource Areas available for extraction represent 13 percent of the total area occupied by sand and gravel deposits in the township and 20 percent of the total resource tonnage.

SELECTED SAND AND GRAVEL RESOURCE AREA 1

Selected Sand and Gravel Resource Area 1 includes both the central portion of the Oak Ridges Moraine along the southern boundary of the township, and the north-trending spur of the moraine which extends past Pontypool. The boundary shown for Area 1 is somewhat generalized because of the limited amount of data available. Further field investigation is required to identify specific areas of high potential for extractive development.

Area 1 is considered to have generally greater potential for further development than the surrounding morainic deposits on the basis of several factors (Gwyn 1976). First, as shown by the concentration of existing pits, the Area is a traditional aggregate source, in contrast to the rest of the moraine which is relatively undeveloped. Second, pit exposures as well as other subsurface data, indicate a greater proportion of coarse granular material in Area 1 than in the surrounding deposit. Finally, the relief of the area is often greater, and the terrain more hummocky and irregular than other portions of the moraine.

In the southern portion of Area 1, twelve pits are currently licenced to operate under The Pits and Quarries Control Act, 1971. The pit faces range in height from 10 to 70 feet (3 to 21 m) and expose generally well sorted and stratified sand and minor amounts of gravel. Only a small proportion of the gravel is greater than 4 inches (10 cm) in diameter and the proportion of "crushable gravel", i.e. that greater than one inch (2.5 cm) in diameter, is quite variable, ranging from 5 to 65 percent (Deike 1978).

The main products from these pits include most types of granular base course aggregate and hot-laid asphaltic sand and stone, as well as pit-and crusher-run gravel of several types. In reference to the southern portion of Area 1, Deike (1978) notes that "Pits in the area contain a very high-quality gravel which is generally suitable for most base and surface paving uses with the exception of H.L. 1, as well as for uses of lesser importance....". Quality constraints on the aggregate relate mainly to the lack of crushable gravel. Selection and sand control are required during excavation to ensure sufficient gravel for crushed products. Blending of different sand grades is also required in some areas to produce acceptable hot-laid aggregates.

There are few competing land uses in the southern portion of Area 1. The hummocky, steeply sloping topography in the area and the susceptibility to erosion and low fertility of soils developed on the moraine give the area low capability for agriculture (Webber, Morwick and Richards 1946). Much of the land is bush covered or has been reforested. Population density, as indicated by air photos and topographic maps, is quite low. In the northern portion of Area 1, north of Concession 2, there are presently no licenced pits. However, inactive and abandoned pits are scattered throughout the area. Ten-to 30-foot (3 to 9 m) faces in these pits expose well sorted and stratified, medium to coarse sand and minor, medium-sized gravel. Crushable gravel ranges from 20 to 35 percent (Deike 1978). The aggregate is suitable for Granular Base Course B and C and other subgrade materials. In many cases, there is insufficient crushable gravel for such products as Granular Base Course A, and 5/8 inch (1.6 cm) crushed stone A and B (Deike 1978).

Agricultural capability is low due to the irregular topography and low soil fertility. Consequently, much of the land is forested. Residential and other development along Highway No. 35 and surrounding Pontypool may sterilize a small proportion of the total resources.

The total resource tonnage in Selected Resource Area 1 is very large. The deposit covers a total area of 4550 acres (1840 ha), exclusive of licenced areas. Deletions for cultural setbacks and areas previously extracted leave an area of 3950 acres (1600 ha) currently available for extraction. Assuming an average deposit thickness of 35 feet (11 m), total sand and gravel resources are estimated to be 345 million tons (313 million tonnes).

Road access to the area is provided by King's Highway No. 35 which runs north-south through the centre of the deposit. Highway No. 35 connects with Highways No. 115 and 401 to the south, providing an excellent haulage route for the transport of aggregate to Toronto markets. Such considerations may account for the recent rapid growth of extraction in the southern portion of Area 1.

SELECTED SAND AND GRAVEL RESOURCE AREA 2

Selected Sand and Gravel Resource Area 2 extends from the northeast corner of the township to the hamlet of Brunswick. The deposit is part of an extensive esker-kame complex which extends north to Fee Landing at the southern end of Pigeon Lake, and may extend north to the shore of Buckhorn Lake in Smith Township (Gravenor 1957, p.30). Gravenor (1957, p. 31) describes the general nature of the esker system as follows:

"Most of the eskers vary greatly in width along their courses. Where they widen the material is generally finer... Where eskers narrow the material is noticeably coarser...".

The main esker ridge in Manvers Township is sinuous, segmented and has several smaller branches. Relief of the ridge ranges from 30 to 75 feet (9 to 23 m), but it has a fairly constant width of 300 to 600 feet (91 to 183 m). A few well developed kame deposits are associated with the esker. A good example is the isolated kame knoll at Fleetwood Station.

Pit face heights throughout the deposit range from 15 to 45 feet (5 to 14 m) and expose moderately sorted pebble to cobble gravel and

sand in the esker ridges, and stratified sand and minor gravel in the lower flanks. Deike (1978) notes that "Sources here are also of very high quality and are suitable for H.L. 4 and higher (quality) hot mix paving purposes".

Quality constraints in the area include an excess of oversize gravel (clasts greater than 4 inches (10 cm) in diameter) in parts of the esker ridges. The oversize component must be removed or crushed in a primary crusher prior to usual processing. In some areas, the crushable aggregate content is low and selection and sand control are required for crushed products.

Selected Resource Area 2 has an area of 550 acres (220 ha) consisting predominantly of the main esker ridges and exclusive of licenced areas. After deletions for cultural setbacks and areas previously extracted, 510 acres (210 ha) remain for extractive development. Assuming an average deposit thickness of 16 feet (5 m), possible resources in Area 2 are estimated to be 20 million tons (18 million tonnes).

Esker deposits in general are well suited for sequential land use since most of the material to be extracted lies above the surrounding ground surface. After extraction, rehabilitation may consist simply of levelling the site.

Although road haulage routes are not direct, several alternate routes are provided by a number of township roads in the area. In addition, a branch line of the Canadian Pacific Railway is close to the Resource Area. Most of the production from the Highland Creek Sand and Gravel Pit (Pit No. 18) is hauled on this line to the Company's handling depot in the east end of Toronto.

SELECTED SAND AND GRAVEL RESOURCE AREA 3

Selected Sand and Gravel Resource Area 3 is located within the southernmost portion of the esker system, just east of Bethany. The dimensions of the esker and the texture of its sediments are much the same as that described for Resource Area 2. A licenced property (Pit No. 17) exposes moderately sorted sand and minor gravel in a 30-foot (9 m) pit face. Deike (1978) indicates that the aggregate is finer-grained than in Area 2 and that the deposit may not be able to supply crushed products.

Resource Area 3 has an area of 200 acres (81 ha), exclusive of licenced areas. Constraints on extraction may be significant in the central portion of the Area. In addition, extensive extraction has taken place in the southern portion and considerable resource tonnage has been removed. Consequently, the area currently available for extraction is 150 acres (61 ha). Assuming an average deposit thickness of 25 feet (8 m), Area 3 has possible resources of approximately 9 million tons (8 million tonnes).

SELECTED SAND AND GRAVEL RESOURCES OF SECONDARY SIGNIFICANCE

Three deposits in central and northwestern Manvers Township have been selected as Sand and Gravel Resource Areas of Secondary Significance. These areas contain significant amounts of aggregate suitable for a variety of local needs and should be given consideration in resource management plans.

The central deposit lies on the eastern flank of Selected Resource Area 1. The area, although extremely irregular and hummocky, is characterized by topography lower than that of Area 1. In the vicinity of Pit No. 16, coarse granular material is found in low irregular ridges with intervening lenses of sand and till. These latter features may be crevasse filling deposits, which are characteristic ice stagnation features (Gravenor 1957, p. 30). Surface exposures and subsurface data are lacking for the remainder of the deposit. Further field investigation is required.

The extensive ice-contact stratified drift deposit that lies to the west of Resource Area 1 has also been selected as a Sand and Gravel Resource Area of Secondary Significance. It is much the same in texture and thickness as the deposit that lies to the east of Area 1. Further field investigation is required to determine areas suitable for extractive development.

The ice-contact deposit in the northwest is exposed along a dissected scarp on the west side of Pigeon River. A large property is licenced to J.R. Vivian in the northern portion of the deposit (Pit No. 19). A 35-foot (11 m) face in the pit exposes clean, medium sand and fine gravel. This licenced pit and the two unlicenced sources in the deposit are given a low to moderate

use rating (Deike 1978). The aggregate is suitable for Granular Base Course B and C, and select subgrade material, but generally not for crushed products. Much of the elevated area to the west of the deposit may consist of similar ice-contact sand and gravel underlying a thick till cap.

BEDROCK GEOLOGY

Manvers Township is underlain by a succession of limestone and shales of Ordovician age referred to as the Lindsay Formation. Although detailed mapping of the bedrock surface is not possible due to the thick drift cover, regional patterns indicate that the bedrock topography is generally smooth and level (Liberty 1969). The formations trend east-west and have a gentle regional dip of 20 to 30 feet to the mile (4 to 6 m to the kilometre) towards the southwest (Liberty 1969, p.86).

The Lindsay Formation consists of grey, fine-grained limestone with abundant interbedded shale. The formation is quarried for lime production at several localities in southern Ontario, such as Picton and Ogden Point on the shore of Lake Ontario (Dolar-Mantuani 1975, p.35). Low freeze-thaw resistance and low abrasion resistance make the Lindsay Formation generally unsuitable for load-bearing crushed stone products.

Drift overlying the Lindsay Formation is generally very thick, ranging from 100 feet (30 m) to more than 300 feet (91 m) in the area of the Oak Ridges Moraine. The drift thickness decreases progressively northwards in the township, and there are several areas along the northern boundary where drift is less than 50 feet (15 m). It is unlikely that quarrying would be established in these areas, because of high stripping costs, distance to market and the limited structural value of the stone.

SELECTED BEDROCK RESOURCES

Bedrock formations in Manvers Township have little value as crushed stone resources. The Lindsay Formation has value mainly for cement production. Drift thickness prohibits quarrying, except in a few isolated areas along the northern boundary of the township. Consequently, no bedrock resource areas have been selected for possible extractive development.

SUMMARY

Manvers Township has no possible bedrock resources and must rely totally on natural sand and gravel deposits for aggregate production. The ice-contact sand and gravel deposits in south-central Manvers Township, and the esker-kame complex in the northeast have been selected for possible resource protection. The Selected Areas have an area available for extraction totalling 4610 acres (1870 ha) with possible resources of approximately 375 million tons (340 million tonnes).

Enquiries regarding the Aggregate Resources Inventory of Manvers Township should be directed to the Ontario Ministry of Natural Resources either at the Lindsay District Office, Lindsay, Ontario, K9V 4T7, (Tel: (705) 324-6121) or at the Central Region Office, Richmond Hill, Ontario, L4C 3C9, (Tel: (416) 884-9203).

TABLE 1 | TOTAL SAND AND GRAVEL RESOURCES, MANVERS TOWNSHIP

1 CLASS NO.	2 DEPOSIT TYPE (See Appendix C)	3 AREAL EXTENT Acres (Hectares)	4 ORIGINAL TONNAGE Millions of Tons (Tonnes)
1	G-E	320 (129)	20 (18)
	G-IC	6400 (2600)	510 (463)
	S-IC	13,300 (5400)	830 (753)
	S-OW	310 (125)	16 (14)
2	G-E	69 (28)	3 (3)
	G-EK	560 (225)	22 (20)
	G-IC	780 (315)	20 (18)
	S-IC	3500 (1420)	140 (127)
	S-LP	4600 (1860)	173 (157)
	S-OW	1780 (720)	67 (61)
3	G-IC	77 (31)	2 (2)
	S-IC	2270 (920)	45 (41)
	G-K	120 (50)	2 (2)
	S-K	44 (18)	<1 (<1)
	S-LP	310 (125)	5 (4)
	S-OW	455 (185)	9 (8)

TABLE 1 | TOTAL SAND AND GRAVEL RESOURCES, MANVERS TOWNSHIP

1 CLASS NO.	2 DEPOSIT TYPE (See Appendix C)	3 AREAL EXTENT Acres (Hectares)	4 ORIGINAL TONNAGE Millions of Tons (Tonnes)
4	S-IC	25 (10)	<1 (<1)
	S-K	65 (26)	<1 (<1)
	S-OW	15 (6)	<1 (<1)
		35,000 (14 200)	1865 (1692)

N. B. Minor variations in above table are due to rounding of data.

TABLE 2 | SAND AND GRAVEL PITS, MANVERS TOWNSHIP

1 NO.	2 MTC NO.	3 OWNER/OPERATOR	4 LOT	5 CON.	6 LICENCED AREAS Acres (Hectares)	7 FACE HEIGHT Feet (Metres)	8 % GRAVEL
LICENCED PITS							
1		Tethany Sand & Gravel Limited	1, 2, 3, 4, 5	1	939 (380.0)	20 (6)	
2	S2-14	Harnden & King Construction	5	1	30.2 (12.2)	20 (6)	
3	S2-15	Harnden & King Construction Limited	6	1	52 (21.0)	20 (6)	
4	S2-49	Bennett Paving Materials Limited	6, 7, 8	1	250 (101.2)	60 (18)	
5	S2-39	Bethany Sand & Gravel Limited	8	1	106 (42.9)	--	
6		Harnden & King	9	1	100 (40.5)	10-15 (3-5)	
7		William E. Reid	10	1	31 (12.6)	15 (5)	
8		William E. Reid	10	1	27.2 (11.0)	--	
9		Oshawa Sand & Gravel	11	1	20 (8.1)	--	
10		Repac Construction	12, 13	1	192 (77.7)	--	
11		Lloyd G. Taylor	13	1	5.3 (2.1)	10 (3)	
12	S2-80	Gordon Kirk	14	1	56 (22.7)	20 (6)	
13	S2-95	Wilfred Richardson	10	3	98 (39.7)	20 (6)	
14		Ivan F. Mountjoy	4	3	100 (40.5)	12 (4)	
15		301070 Ontario Limited	9, 10	5	196.2 (79.4)	30 (9)	
16	S2-11	T. Veenhof	15	6	99.5 (40.3)	15 (5)	

TABLE 2 | SAND AND GRAVEL PITS, MANVERS TOWNSHIP

1 NO.	2 MTC NO.	3 OWNER/OPERATOR	4 LOT	5 CON.	6 LICENCED AREAS Acres (Hectares)	7 FACE HEIGHT Feet (Metres)	8 % GRAVEL
17		Charles Palmer	24	8	23 (9.3)	30 (9)	
18		Highland Creek Sand & Gravel	22, 23 23, 24	10 11	476 (192.6)	10 (3)	
19	S2-94	J. R. Vivian	6, 7	11	85 (34.4)	35 (11)	
20		Township of Manvers	15	6	6.5 (2.6)	15 (5)	
					2892.9 (1170.8)		
UNLICENCE PITS							
21	S2-128	McGill	6	11		35 (11)	
22	S2-59	W. Heaslip	6	10		8-10 (2-3)	
23	S2-130	Preston #2	10	10		40 (12)	
24	S2-3	Murray Spiers #2	24	12		10 (3)	
25	S2-145	Popovic	25	12		10 (3)	
26	S2-120	Capstick	24	9		10 (3)	
27	S2-3	H. Green	24	7		30-50 (9-15)	
28	S2-5	Smith	24	7		10-20 (3-6)	
29	S2-37	Lapinski	25	3		20-35 (6-11)	
30	S2-105	Armstrong (Veenholf)	15	7		10 (3)	

TABLE 2 | SAND AND GRAVEL PITS, MANVERS TOWNSHIP

1 NO.	2 MTC NO.	3 OWNER/OPERATOR	4 LOT	5 CON.	6 LICENCED AREAS Acres (Hectares)	7 FACE HEIGHT Feet (Metres)	8 % GRAVEL
31	S2-17	Curtis	13, 14	5		20 (6)	
32	S2-8	G. Chapman	12, 13	4		9 (3)	
33	S2-6	Lloyd Fallis	12	5		10 (3)	
34	S2-143	W. Mitchell	12	5		--	
35	S2-77	Mitchell	11	5		--	
36	S2-26	McMahon	11	3		10 (3)	
37	S2-48	B. Brown	7	3		--	
38	S2-81	Manetta	12	2		15 (5)	
39	S2-51	White	11	2		--	
40	S2-33	A. Brown	15	1		13 (4)	
41	S2-127	Nicholson	5	14		10 (3)	

TABLE 3 | SELECTED SAND AND GRAVEL RESOURCE AREAS, MANVERS TOWNSHIP

1 DEPOSIT NO.	2 UNLICENCED AREA Acres (Hectares)	3 CULTURAL SETBACKS Acres (Hectares)	4 EXTRACTED AREA Acres (Hectares)	5 AVAILABLE AREA Acres (Hectares)	6 ESTIMATED DEPOSIT THICKNESS Feet (Metres)	7 AVAILABLE AGGREGATE Millions of Tons (Tonnes)
1	4550 (1840)	580 (235)	20 (8)	3950 (1600)	35 (11)	345 (313)
2	550 (220)	35 (14)	5 (2)	510 (210)	16 (5)	20 (18)
3	200 (81)	35 (14)	15 (6)	150 (61)	25 (8)	9 (8)
	5300 (2140)	650 (260)	40 (16)	4610 (1870)		375 (340)

N. B. Minor variations in above table are due to rounding of data.

TABLE 4 | TOTAL IDENTIFIED BEDROCK RESOURCES, MANVERS TOWNSHIP

1 DRIFT THICKNESS Feet (Metres)	2 FORMATION	3 WORKABLE THICKNESS Feet (Metres)	4 AREAL EXTENT Acres (Hectares)	5 ORIGINAL TONNAGE Millions of Tons (Tonnes)
Outcrop	Lindsay	60 (18)	--	--
0-25 (0-8)	Lindsay	60 (18)	-- --	-- --
25-50 (8-15)	Lindsay	60 (18)	900 (365)	194 (176)
			900 (365)	194 (176)

N. B. Minor variations in above table are due to rounding of data.

TABLE 5 QUARRIES, MANVERS TOWNSHIP

1 NO.	2 MTC NO.	3 OWNER/OPERATOR	4 LOT	5 CON.	6 LICENCED AREA Acres (Hectares)	7 FACE HEIGHT Feet (Metres)
		- NONE -				

TABLE 6 | SELECTED BEDROCK RESOURCE AREAS, MANVERS TOWNSHIP

1 DEPOSIT NO.	2 DEPTH OF OVERBURDEN Feet (Metres)	3 UNLICENCED AREA Acres (Hectares)	4 CULTURAL SETBACKS Acres (Hectares)	5 EXTRACTED AREA Acres (Hectares)	6 AVAILABLE AREA Acres (Hectares)	7 ESTIMATED WORKABLE THICKNESS Feet (Metres)	8 AVAILABLE TONNAGE Millions of Tons (Tonnes)
- NONE -							

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1977: Mineral Aggregate Study and Geological Inventory, Southwestern Region of Ontario; Prepared for the Ontario Ministry of Natural Resources, about 200 p., some coloured maps.

APPENDIX B-GLOSSARY

ABRASION RESISTANCE

Tests such as the Los Angeles Abrasion Test are used to measure the ability of aggregate to resist crushing and pulverizing under conditions similar to those encountered in processing and use. Measuring resistance is an important component in the evaluation of the quality and prospective uses of aggregate. Hard, durable material is preferred for road building.

ABSORPTION CAPACITY

Related to the porosity of the rock types of which an aggregate is composed. Porous rocks are subject to disintegration when absorbed liquids freeze and thaw, thus decreasing the strength of the aggregate.

AGGREGATE

Any hard, inert, construction material (sand, gravel, shells, slag, crushed stone or other mineral material) used for mixing in various sized fragments with a cement or bituminous material to form concrete, mortar, etc., or used alone for road building or other construction. Synonyms include mineral aggregate and granular material.

CAMBRIAN

The first Period of the Paleozoic Era, thought to have covered the time between 570 and 500 million years ago; the Cambrian precedes the Ordovician Period.

CLAST

An individual constituent, grain, or fragment of a sediment or rock, produced by the mechanical weathering of a larger rock mass. Synonyms include particle and fragment.

DELETERIOUS LITHOLOGY

A general term used to designate those rock types which are chemically or physically unsuited for use as construction or road-building aggregates. Such lithologies as chert, shale, siltstone, and sandstone may deteriorate rapidly when exposed to traffic and other environmental conditions.

DEVONIAN

A Period of the geological past thought to have covered the span of time between 395 and 345 million years ago, following the Silurian Period. Rocks formed in the Devonian Period are among the youngest found in Ontario.

DIRT

See fines.

DOLOSTONE

A carbonate sedimentary rock consisting chiefly of the mineral dolomite and containing relatively little calcite (dolostone is also known as dolomite).

DRIFT

A general term for all unconsolidated rock debris transported from one place and deposited in another; distinguished from underlying bedrock. In North America, glacial activity has been the dominant mode of transport and deposition of drift. Synonyms include overburden and surficial deposit.

DRUMLIN

A low, smoothly rounded, elongated hill, mound, or ridge composed of glacial materials. These landforms were deposited beneath an advancing ice sheet, and were shaped by its flow.

EOLIAN

Pertaining to the wind, especially with respect to landforms whose constituents were transported and deposited by wind activity. Sand dunes are an example of an eolian landform.

FINES

A general term used to describe the size fraction of an aggregate which passes (is finer than) the No.200 mesh screen (0.074 mm). Also described informally as "dirt", these particles are in the silt- and clay-size range.

GLACIAL LOBE

A tongue-like projection from the margin of the main mass of an ice cap or ice sheet. During the Pleistocene Epoch several lobes of the Laurentide continental ice sheet occupied the Great Lakes basins. These lobes advanced and retreated numerous times during the Pleistocene, producing the complex arrangement of glacial material and landforms found in southern Ontario.

GRADATION

The proportion of material of each particle size, or the frequency distribution of the various sizes which constitute a sediment. The strength, durability, permeability and stability of an aggregate depend to a great extent on its gradation. The size limits for different particles are as follows:

Boulder		>-256 mm
Gravel	cobble	64-256 mm
Gravel	pebble	4-64 mm
Gravel	granule	2-4 mm
Sand	coarse	.5-2 mm
	medium	.25-.5 mm
	fine	.074-.25 mm
Silt, clay		<.074 mm

GRANULAR BASE COURSE

Components of the pavement structure of a road, which are placed on the subgrade and are designed to provide strength, stability, and drainage, as well as support for surfacing materials. Several types have been defined: Granular Base Course A consists of crushed and processed aggregate and has relatively stringent quality standards in comparison to Granular Base Course B and C which are usually pit-run or other unprocessed aggregate.

H.L. (HOT-LAID OR ASPHALTIC AGGREGATE)

Bituminous, cemented aggregates used in the construction of pavements either as surface or bearing course (H.L. 1, 3, and 4), or as binder course (H.L. 2, 6, and 8) used to bind the surface course to the underlying granular base course.

LITHOLOGY

The description of rocks on the basis of such characteristics as color, structure, mineralogic composition, and grain size. Generally, the description of the physical character of a rock.

MELTWATER CHANNEL

A drainage way, usually terraced, produced by water flowing away from a melting glacier margin.

ORDOVICIAN

An early period of the Paleozoic Era thought to have covered the span of time between 500 and 435 million years ago.

PALEOZOIC ERA

One of the major divisions of the geologic time scale thought to have covered the time between 570 and 230 million years ago. The Paleozoic Era (or Ancient Life Era) is subdivided into six geologic Periods, of which only four (Cambrian, Ordovician, Silurian, and Devonian) can be recognized in southern Ontario.

PLEISTOCENE

An Epoch of the recent geological past including the time from approximately 1.8 million years ago to 7000 years ago. Much of the Pleistocene was characterized by extensive glacial activity.

POSSIBLE RESOURCE

Reserves estimates based largely on broad knowledge of the geologic character of the deposit and for which there are few, if any samples or measurements. The estimates are based on assumed continuity or repetition for which there are reasonable geological indications.

SHALE

A fine-grained, sedimentary rock formed by the consolidation of clay, silt, or mud and characterized by well developed bedding planes, along which the rock breaks readily into thin layers. The term shale is also commonly used for fissile claystone, siltstone, and mudstone.

SILURAIN

An early Period of the Paleozoic Era thought to have covered the time between 435 and 395 million years ago. The Silurian follows the Ordovician Period and precedes the Devonian Period.

SOUNDNESS

The ability of the components of an aggregate to withstand the effects of various weathering processes and agents. Unsound lithologies are subject to disintegration caused by the expansion of absorbed solutions. This may seriously impair the performance of road-building and construction aggregates.

TILL

Unsorted and unstratified rock debris, deposited directly by glaciers, and ranging in size from clay to large boulders.

WISCONSINAN

Pertaining to the last glacial stage of the Pleistocene Epoch in North America. It began approximately 85,000 years ago and ended approximately 7000 years ago. The glacial deposits and landforms of southern Ontario are predominantly the result of glacial activity during the Wisconsinan Stage.

APPENDIX C-GEOLOGY OF SAND AND GRAVEL DEPOSITS

The type, distribution, and extent of sand and gravel deposits in southern Ontario are the result of extensive glacial and glacially influenced activity in Wisconsinan time during the Pleistocene Epoch, approximately 7000 to 85 000 years ago. The deposit types reflect the different depositional environments that existed during the melting and retreat of the continental ice masses, and they can readily be differentiated on the basis of their morphology, structure, and texture. The deposit types are described below.

GLACIOFLUVIAL DEPOSITS

These deposits can be divided into two broad categories: those that were formed in contact with (or in close proximity to) glacial ice, and those that were deposited by meltwaters carrying materials beyond the ice margin.

ICE-CONTACT TERRACES (ICT)

These are glaciofluvial features deposited between the glacial margin and a confining topographic high, such as the side of a valley, The structure of the deposits may be similar to that of outwash deposits, but in most cases the sorting and grading of the material is more variable and the bedding is discontinuous due to extensive slumping. The probability of locating large amounts of crushable aggregate is moderate, and extraction may be expensive due to the variability of the deposits both in terms of quality and grain-size distribution.

KAMES (K)

Kames are defined as mounds of poorly sorted sand and gravel deposited by meltwater in depressions or fissures on the ice surface or at its margin. During glacial retreat, the melting of supporting ice causes collapse of the deposits producing internal structures characterized by bedding discontinuities. The deposits consist mainly of irregularly bedded and cross-bedded, poorly sorted sand and gravel. The present forms of the deposits include single mounds, linear ridges (crevasse fillings) or complex groups of landforms. The latter are occasionally described as "undifferentiated ice-contact stratified drift" (IC) when detailed subsurface information is unavailable. Since kames commonly contain large amounts of fine-grained material and are characterized by considerable variability, there is generally a low to moderate probability of discovering large amounts of good-quality, crushable aggregate. Extractive problems encountered in these deposits are mainly the excessive variability of the aggregate and the rare presence of excess fines (silt-and clay-sized particles).

ESKERS (E)

Eskers are narrow, sinuous ridges of sand and gravel deposited by meltwaters flowing in tunnels within or at the base of glaciers, or in channels on the ice surface. They vary greatly in size. Many, though not all eskers consist of a central core of poorly sorted and stratified gravel characterized by a wide range in grain size. The core material is often draped on its flanks by better sorted and stratified sand and gravel. The deposits have a high probability of containing a large proportion of crushable aggregate, and since they are generally built above the surrounding ground surface, are convenient extraction sites. For these reasons esker deposits have been traditional aggregate sources throughout southern Ontario, and are significant components of the total resources of many areas.

Some planning constraints and opportunities are inherent in the nature of the deposits. Because of their linear nature, the deposits commonly extend across several property boundaries leading to unorganized extractive development at numerous small pits. On the other hand, because of their form, eskers can be easily and inexpensively extracted and are amenable to rehabilitation and sequential land use.

UNDIFFERENTIATED ICE-CONTACT STRATIFIED DRIFT (IC)

This designation may include deposits from several ice-contact, depositional environments which usually form extensive, complex landforms. It is not feasible to identify individual areas of coarse-grained material within such deposits due to their lack of continuity and grain-size variability. They are given a qualitative

rating based on existing pit and other subsurface data.

OUTWASH (OW)

Outwash deposits consist of sand and gravel laid down by meltwaters beyond the margin of the ice lobes. They occur as sheets or as terraced valley fills (valley trains) and may be very large in extent and thickness. Well developed outwash deposits have good horizontal bedding and are uniform in grain-size distribution. Outwash deposited near the glacier's margin is much more variable in texture and structure. The probability of locating useful crushable aggregates in outwash deposits is moderate to high depending on how much information on size, distribution and thickness is available.

ALLUVIUM (AL)

Alluvium is a general term for clay, silt, sand, gravel, or similar unconsolidated material deposited during postglacial time by a stream as sorted or semi-sorted sediment, on its bed or on its floodplain. The probability of locating large amounts of crushable aggregate in alluvial deposits is low, and it has generally low value due to the presence of excess silt- and clay-sized material. There are no large postglacial alluvium deposits in Ontario.

GLACIOLACUSTRINE DEPOSITS

GLACIOLACUSTRINE BEACH DEPOSITS (LB)

These are relatively narrow, linear features formed by wave action at the shores of glacial lakes that existed at various times during the deglaciation of southern Ontario. Well developed lacustrine beaches are usually less than 20 feet (6 m) thick. The aggregate is well sorted and stratified and sand-sized material commonly predominates. The composition and size distribution of the deposit depends on the nature of the underlying material. The probability of obtaining crushable aggregate is high when the material is developed from coarse-grained materials such as a stony till, and low when developed from fine-grained materials. Beaches are relatively narrow, linear deposits, so that extractive operations are often numerous and extensive.

GLACIOLACUSTRINE DELTAS (LD)

These features were formed where streams or rivers of glacial meltwater flowed into lakes and deposited their suspended sediment. In southern Ontario such deposits tend to consist mainly of sand and abundant silt. However, in near-ice and ice-contact positions, coarse material may be present. Although deltaic deposits may be large, the probability of obtaining coarse material is generally low.

GLACIOLACUSTRINE PLAIN (LP)

The nearly level surface marking the floor of an extinct glacial lake. The sediments which form the plain are predominantly fine to medium sand, silt, and clay, and were deposited in relatively deep water. Lacustrine deposits are generally of low value as aggregate sources due to their fine grain size and lack of crushable material. In some aggregate-poor areas, lacustrine deposits may constitute valuable sources of fill and some granular base course aggregate.

GLACIAL DEPOSITS

END MORAINES (EM)

These are belts of glacial drift deposited at, and parallel to, glacier margins. They commonly consist of ice-contact stratified drift and in such instances are usually called kame moraines. Kame moraines commonly result from deposition between two glacial lobes (interlobate moraines). The probability of locating aggregates within such features is moderate to low. Exploration and development costs are high. Moraines may be very large and contain vast aggregate resources, but the location of the best resource areas within the moraine is usually poorly defined.

EOLIAN DEPOSITS

WINDBLOWN FORMS (WD)

Windblown deposits are those formed by the transport and deposition of sand by winds. The form of the deposits ranges from extensive, thin layers to well developed linear and crescentic ridges known as dunes. Most windblown deposits in southern Ontario are derived from,

and deposited on , pre-existing lacustrine sand plain deposits. Windblown sediments are almost invariably composed of fine to coarse sand and are usually well sorted. The probability of locating crushable aggregate in windblown deposits is very low.

APPENDIX D-GEOLOGY OF BEDROCK DEPOSITS

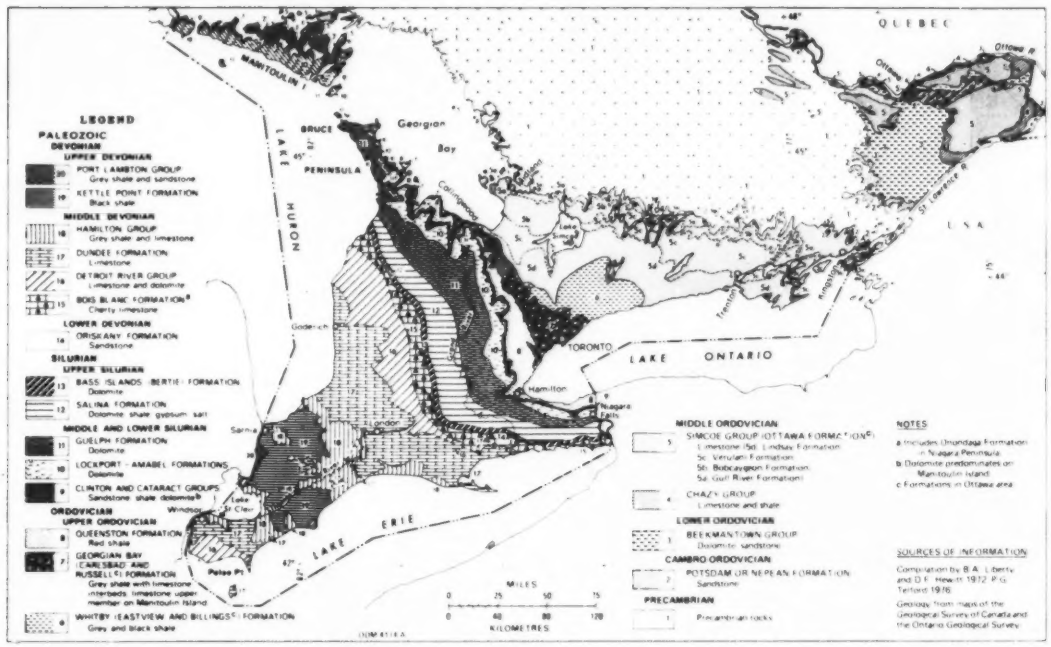


Figure 2 - Bedrock Geology of Southern Ontario

BEDROCK SUITABLE FOR CRUSHED STONE PRODUCTS

BASS ISLANDS FORMATION (UPPER SILURIAN)

(Includes the Bertie Formation of the Niagara Peninsula) Composition: Medium- to massive-bedded, aphanitic, brown dolostone with shaly partings. Thickness: 35 to 60 feet (11-18m) near Hagersville. Uses: Quarried for crushed stone on the Niagara Peninsula at Fort Erie, Cayuga, Hagersville, and Dunville. Los Angeles Abrasion Test: 17-35% loss; Absorption: 1.4%. Shaly parts are unsuitable for aggregate due to high soundness losses.

BOBCAYGEON FORMATION (MIDDLE ORDOVICIAN)

Composition: Compact, homogeneous, medium- to thin-bedded, fine-grained limestone with some argillaceous and shaly partings. Thickness: The lower unit is 40 to 72 feet (12 to 22 m) thick in the east and the remainder of the formation is 40 feet (12 m). Uses: Quarried at Kirkfield and Marysville for crushed stone. The Bobcaygeon Formation has consistently acceptable quality for granular base course materials and concrete.

BOIS BLANC FORMATION (LOWER-MIDDLE DEVONIAN)

Composition: Brownish grey, medium-crystalline, medium- to thin-bedded, cherty limestone, commonly fossiliferous. Limestone may be silty or sandy in places. Thickness: 9 to 200 feet (3 to 61 m). Uses: Quarried at Hagersville, Cayuga, and Port Colborne for crushed stone. High chert content makes much of the material unsuitable for concrete aggregate. Los Angeles Abrasion

Test: 14-28% loss; Soundness Test: 4-10% loss; Absorption: 0.7-2.0%.

DUNDEE FORMATION (MIDDLE DEVONIAN)

Composition: Fine- to medium-crystalline, brown ish grey, medium- to thick-bedded, dolomitic limestone with shaly partings, sandy layers, and chert in some areas. Thickness: 60 to 160 feet (18 to 49 m). Uses: Quarried near Port Dover and Pelee Island for crushed stone. Used at St. Marys for portland cement. Los Angeles Abrasion Test: 22-32% loss; Absorption: 0-4%.

GULL RIVER FORMATION (MIDDLE ORDOVICIAN)

Composition: Member A: thin-to thick-bedded, interbedded, grey argillaceous limestone and buff to green dolostone with a maximum thickness of 60 feet (18 m). Members B and C are dense, aphanitic limestones with argillaceous dolostone interbeds. Uses: Quarried at Kirkfield, Victoria County, and Uthoff for crushed stone. The product is generally fresh and compact with good cubic-shaped factor, low clay content, low absorption, and low soundness losses. Smooth particle surfaces may cause adhesion problems for asphalt. There is some alkali reactivity in a few of the layers.

LOCKPORT AND AMABEL FORMATIONS (MIDDLE SILURIAN)

Composition: Amabel Formation (Georgetown to the Bruce Peninsula): massive, fine crystalline dolostone, with reef facies dolostone near Georgetown. Lockport Formation (lateral facies equivalent to the Amabel Formation from Georgetown to Niagara Falls): thin- to massive-bedded, fine- to medium-grained dolostone. Thickness: Amabel Formation: maximum observed thickness of 84 feet (26 m). Lockport Formation: up to 130 feet (40 m). Uses: The Lockport and Amabel Formations have been used to produce lime, crushed stone, and building stone throughout their area of occurrence, and are a valuable aggregate resource. Los Angeles Abrasion Test: 21-35% loss; Soundness Test: 2.0% loss; Absorption: 0.4-1.6%.

ONONDAGA FORMATION (MIDDLE DEVONIAN)

(Equivalent to the Detroit River Group, with a textural change) Composition: Edgecliffe Member: medium-bedded, fine- to medium-grained, dark grey cherty limestone with an estimated thickness of 25 to 30 feet (8 to 9 m). Clarence Member: massive-bedded, dark grey brown, fine-grained, very cherty limestone having an estimated thickness of 26 feet (8 m). Moorehouse Member: medium-bedded, dark grey brown or purplish brown, fine- to coarse-grained, variably cherty limestone with an estimated thickness of 15 to 25 feet (5 to 8 m). Uses: Quarried for crushed stone on the Niagara Peninsula at Welland and Port Colborne. High chert content makes much of the material unsuitable for concrete aggregate.

OTTAWA FORMATION (MIDDLE ORDOVICIAN)

Composition: Lower Phase (Lowville and Pamela Beds): shale, some sandstone and dolostone. Thickness: 100 feet (30 m). Middle Phase (Hull, Rockland, and Leray Beds): pure, thick-bedded, crystalline limestone. Thickness: 150 feet (46 m) near Ottawa. Upper Phase (Cobourg and Sherman Fall Beds): pure and impure crystalline limestone with few to numerous shaly partings, 450 to 475 feet (137-145 m) thick near Ottawa. Uses: The Leray, Rockland, and Hull Beds have been quarried extensively for crushed stone and for building stone. In addition, the Hull Beds are an excellent source of lime for cement production and agricultural uses.

OXFORD FORMATION (LOWER ORDOVICIAN)

Composition: Medium- to thick-bedded, grey dolostone, with some shaly partings. Thickness: 240 feet (73 m). Uses: Quarried for crushed stone (road and concrete aggregate) at Ottawa, Brockville, and Smiths Falls.

BEDROCK SUITABLE FOR LIME PRODUCTION AND OTHER CHEMICAL USES.

DETROIT RIVER GROUP (MIDDLE DEVONIAN)

(Equivalent to the Onondaga Formation in the Niagara Peninsula, with a textural change). Composition: Near Beachville, the group consists of medium- to micro-crystalline, medium-bedded, high purity limestone. It grades northwards near St. Marys to soft, evenly bedded, fine-grained dolostone with bituminous laminae. Massive, porous, reef facies material also occurs to the north (Formosa Reef Limestone). Thickness: 100 feet (30 m) at Beachville, 350 feet (107 m) at Clinton. Uses: The most important

source of high purity limestone in Ontario is the Lucas Formation of the Detroit River Group at Beachville. Detroit River limestone produces 80% of Ontario's cement. Its dolomitic reefal facies is also important for lime production to the north. It is generally unsuitable for crushed stone. The Anderdon Member of the Lucas Formation is quarried at Amherstburg for crushed stone.

GRENVILLE MARBLE (PRECAMBRIAN)

Composition: Recrystallized white limestone and dolostone, fine- to coarse-grained, usually of high chemical purity. Uses: Lime production, but also in small amounts for terrazo chips, poultry grit, decorative stone, and building stone.

GUELPH FORMATION (MIDDLE SILURIAN)

Composition: Aphanitic- to medium-crystalline, thick-bedded, soft, porous dolostone, characterized in places by extensive vuggy, porous reefal facies dolostone of high chemical purity. The Guelph Formation and the underlying Amabel Formation have a combined thickness of 200 feet (61 m) on the Niagara Peninsula and more than 400 feet (122 m) on the Bruce Peninsula. Uses: The main use is for dolomitic lime in the construction industry. It is quarried at Glen Christie and Guelph.

LINDSAY FORMATION (MIDDLE ORDOVICIAN)

Composition: Lower Member: fine-crystalline, rubbly, nodular, weathering limestone. Upper Member: grey calcareous claystone with shaly partings and bioclastic layers. The rock is "soft" and weathers to rubble. Both members are characterized by low dolomite content and by numerous clayey partings. Uses: Quarried at Picton, Ogden Point, Colborne, and Bowmanville for lime. It is generally unsuitable for crushed stone, concrete aggregate, or granular base course.

VERULAM FORMATION (MIDDLE ORDOVICIAN)

Composition: Fossiliferous, pure to argillaceous limestone and interbedded calcareous shale. The rock is not resistant to erosion and commonly weathers to rubble. Thickness: 200-300 feet (61-91 m). Uses: Quarried at Picton, Ogden Point, and Mara Township for lime. It is unsuitable for crushed stone due to clay impurities and many clayey interbeds, low abrasion resistance, high soundness losses and poor freeze-thaw resistance.

BEDROCK SUITABLE FOR BRICK AND TILE MANUFACTURE

GEORGIAN BAY FORMATION (UPPER ORDOVICIAN)

(Formerly known as the Meaford-Dundas and Blue Mountain shales in the Toronto and Bruce Peninsula areas). Composition: Soft, fissile, blue grey shale with limey or sandy lenses in a few places. Thickness: 640 feet (195 m) at Toronto. Uses: Five producers in Metro Toronto and Cooksville produce brick and structural tile (Guillet 1967). Lightweight aggregate is also produced at Streetsville by heat expansion of the shale.

HAMILTON GROUP (MIDDLE DEVONIAN)

Composition: Grey shale with interbeds of crystalline and cherty limestone. The Group has six formations. Only the Arkona is of commercial value. It is a soft, light grey, calcareous shale which is plastic and easily worked when wet. Thickness: 80 to 300 feet (24 to 91 m). Uses: The Arkona Formation is extracted at Thedford and near Arkona for production of drainage tile and brick.

QUEENSTON FORMATION (UPPER ORDOVICIAN)

Composition: Red, thin- to thick-bedded, sandy to argillaceous shale with green mottling and banding. Thickness: 400 to 500 feet (122 to 152 m). Uses: There are 12 large shale quarries developed in the Queenston Formation in the Toronto-Hamilton region and one at Russell, near Ottawa (Guillet 1967). All produce brick for construction. The Queenston Formation is the most important source material for brick manufacture in the Province.

BEDROCK SUITABLE FOR OTHER INDUSTRIAL PRODUCTS

NEPEAN (POTSDAM) FORMATION (CAMBRO-ORDOVICIAN)

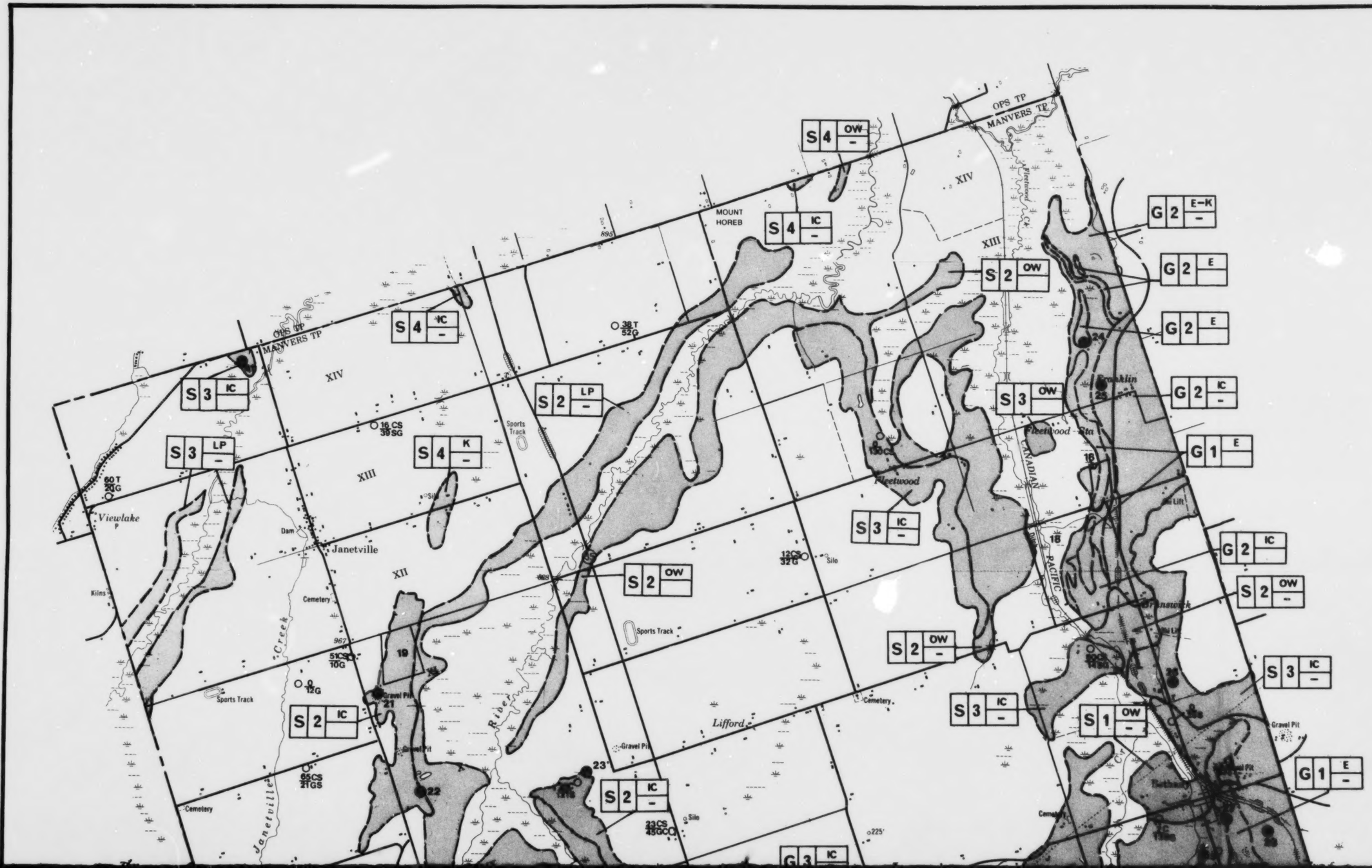
Composition: Creamy, coarse-grained, silica sandstone. Uses: Quarried throughout its area of outcrop for building stone, decorative stone, abrasives, and for glass making.

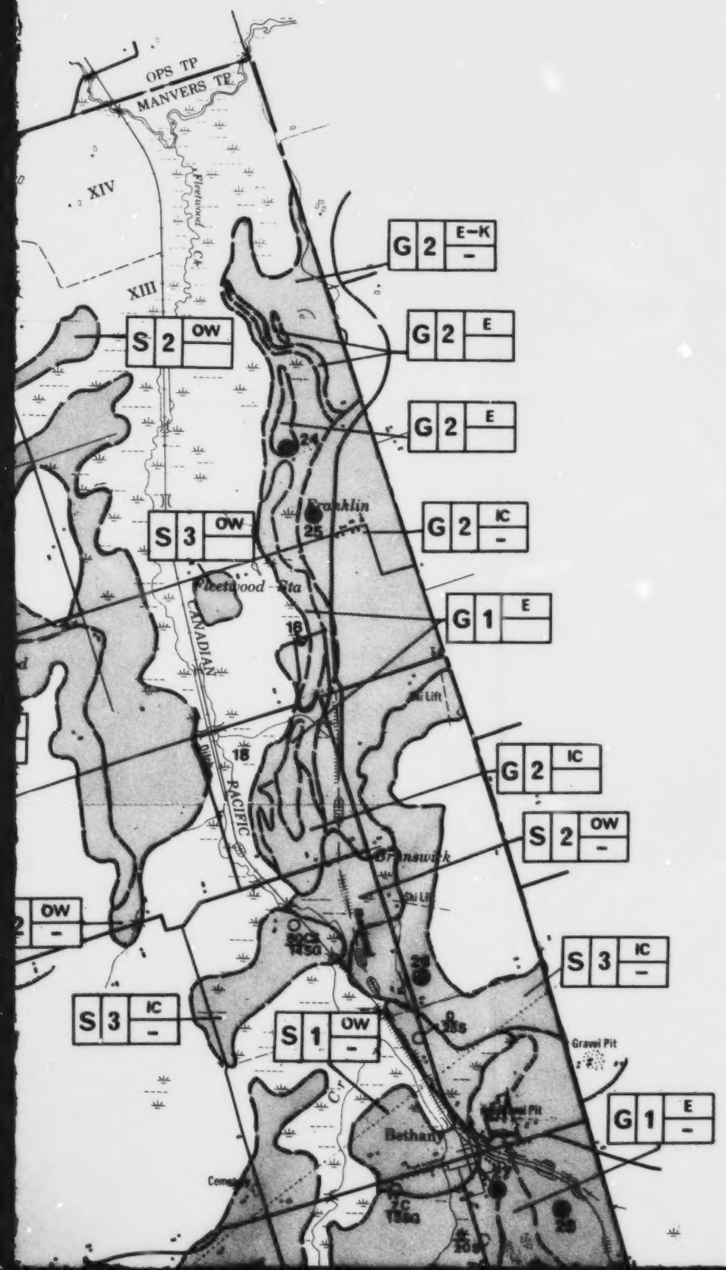
SALINA FORMATION (UPPER SILURIAN)

Composition: Grey and red shale, brown dolomite, and, in places, salt, anhydrite, and gypsum. The formation consists predominantly of evaporite deposits with up to eight members identified. Uses: Gypsum is mined at Hagersville, Caledonia, and Drumbo. Salt is mined at Goderich and is produced from brine wells at Amhertsburg, Windsor, and Sarnia.

WHITBY FORMATION (UPPER ORDOVICIAN)

(Formerly known as Collingwood Shale near Toronto). Composition: Brown to black fissile shale. Uses: Quarried at Bowmanville for use in cement production. Testing indicates that the Whitby Formation may produce satisfactory lightweight expanded aggretage.


OPS TP
MANVERS TP
MOUNT HOREB
XIV
XIII
XII
Viewlake
Janetville
Fleetwood
Fleetwood Sta
Lifford
Bethany
Franklin
Creek
River
Sports Track
Cemetery
Gravel Pit
Silo
Dam
Kilns
CANADIAN PACIFIC
S 4 OW –
S 4 IC –
S 3 IC –
S 3 LP –
S 4 K –
S 2 LP –
S 2 OW –
S 2 IC –
S 3 OW –
S 1 OW –
G 2 E-K –
G 2 E
G 2 IC –
G 1 E
G 3 IC –



Ministry of Natural Resources

Hon. James A.C. Auld
Minister

Dr. J.K. Reynolds
Deputy Minister

Ontario

ONTARIO GEOLOGICAL SURVEY
AGGREGATE RESOURCES INVENTORY

MANVERS TOWNSHIP

VICTORIA COUNTY

MAP 1
DISTRIBUTION OF SAND AND GRAVEL DEPOSITS

Scale: 1:50,000

Mile 1 0 1 Mile
Metres 1000 0 1 Kilometre

NTS Reference. **31 D/2, 31 D/7**

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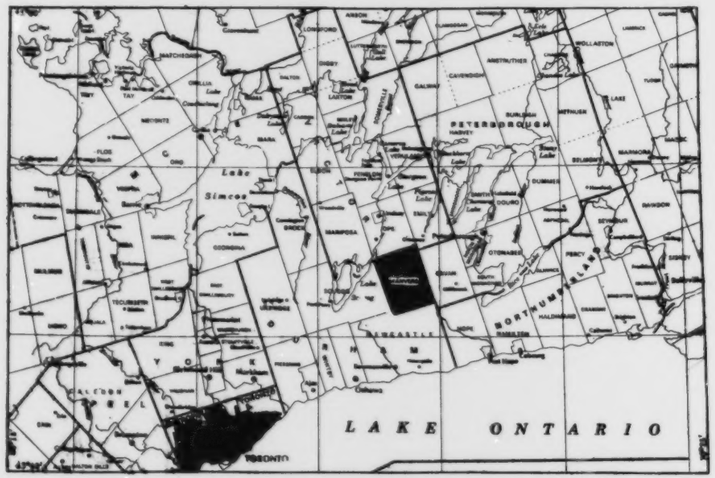
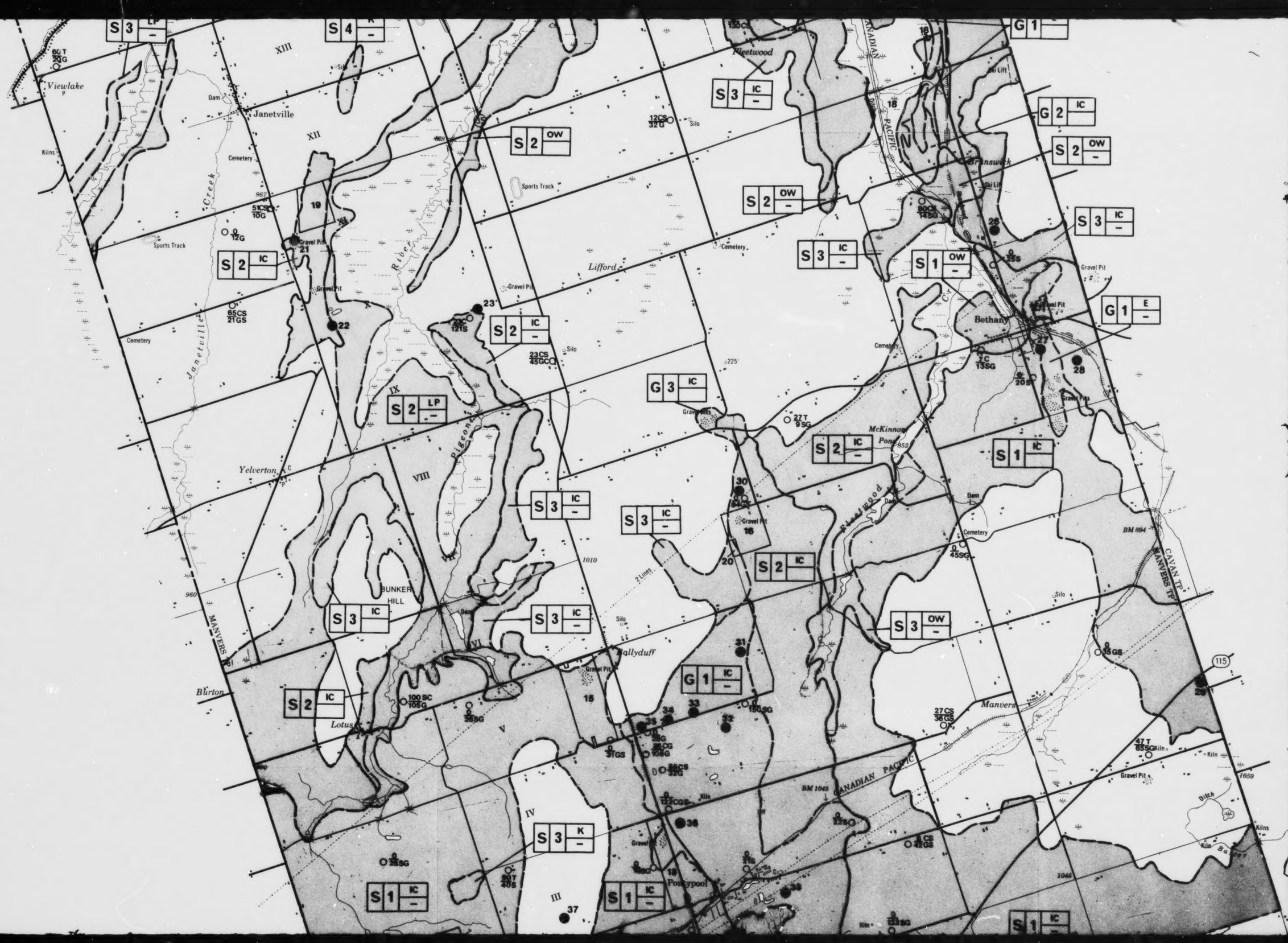


SYMBOLS

Geological and aggregate thickness boundary. Shading indicates

Thickness Class

Class	Average Thickness in feet	Tons per acre


Viewlake
Janetville
Kilns
Cemetery
Sports Track
Gravel Pit
Dam
Silo
Lifford
Fleetwood
Bethany
Brunswick
McKinnon Pond
Yelverton
BUNKER HILL
Ballyduff
Blirton
Lotus
Manvers
Pontypool
Janetville Creek
Pigeon River
MANVERS TP
CAVAN TP
CANADIAN PACIFIC
S 3 LP –
S 4 K –
S 2 OW –
S 2 IC –
S 3 IC –
S 2 LP –
S 3 K –
S 1 IC –
S 1 OW –
G 1 –
G 2 IC
G 3 IC
G 1 IC –
G 1 E –
S 1 IC
S 3 OW –
S 2 IC
S 3 IC
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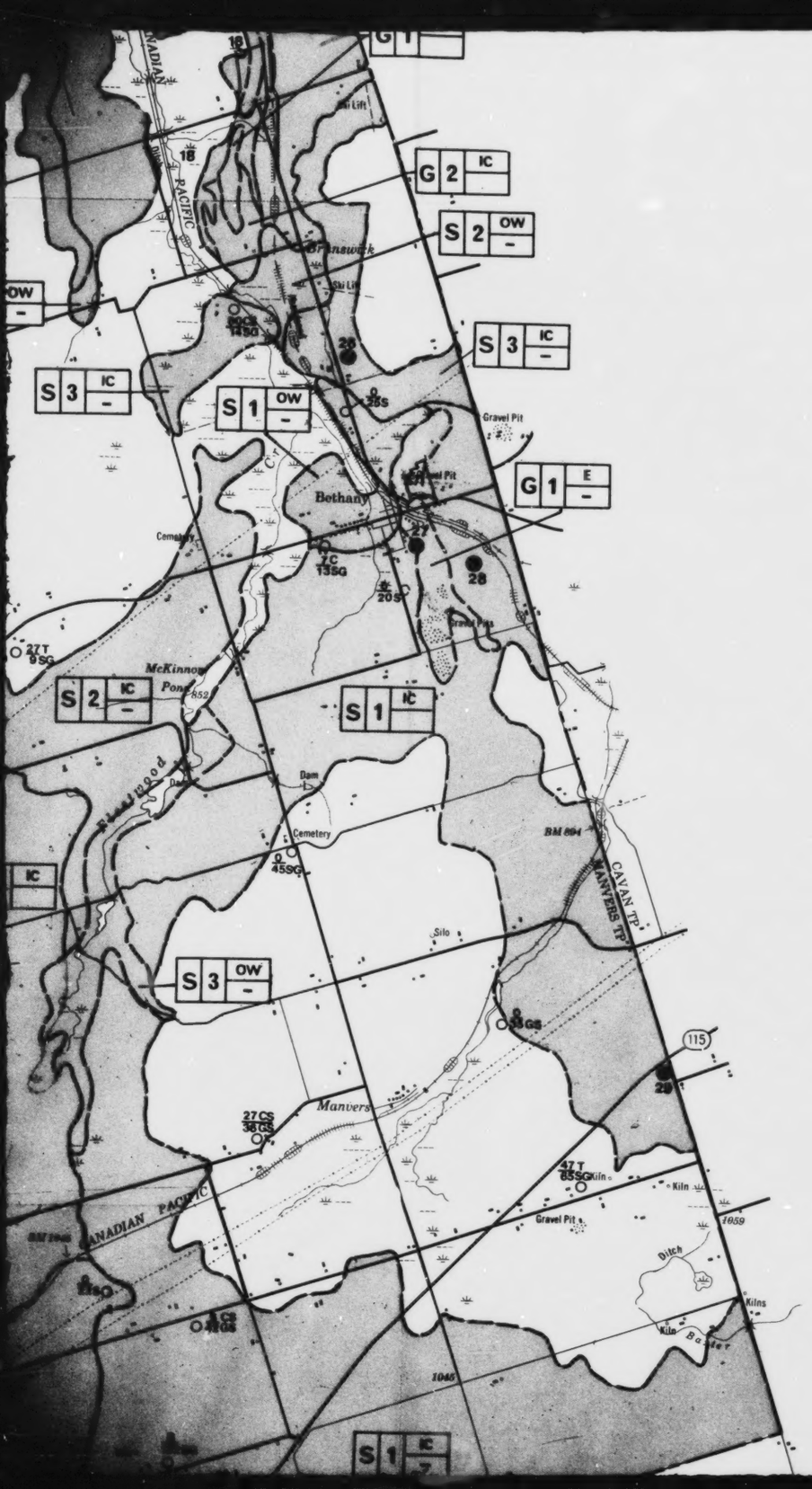
S 1 IC
S 3 OW



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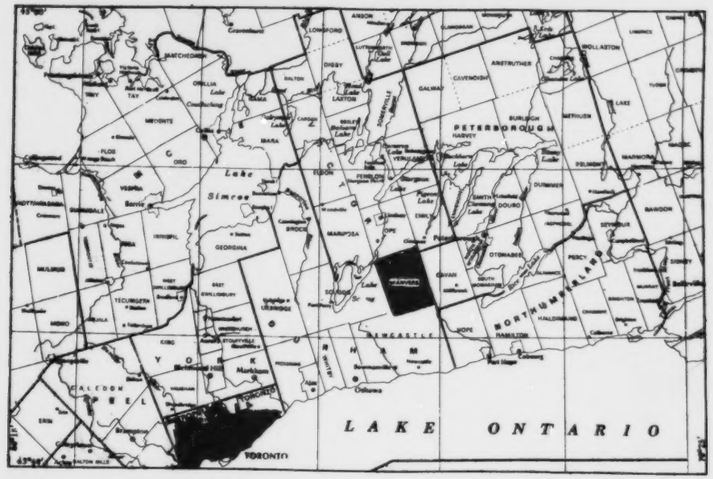


SYMBOLS

Geological and aggregate thickness boundary. Shading indicates deposit area.

S1 IC CLO — Deposit symbol: see below.

3 — Licenced property boundary; Property number: see Table 2.

●4 — Unlicenced sand or gravel pit; Property number: See Table 2.

6/23 — Selected drilling location indicating thickness of overburden overlying reported thickness of granular materials (in feet). (Note: S-sand, G-gravel, C-clay, T-till)

DEPOSIT SYMBOL

Deposits are identified by gravel content, thickness class, deposit type and quality indicators. Gravel content is expressed as percentage of crushable material. Classes are based on potential aggregate tonnage per acre and are designated numerically. Type refers to geologic origin. Quality modifiers indicate variations in grain size distribution and lithology.

Gravel Content	Thickness Class	Geological Type
		Quality Indicators

Gravel Content

G	Greater than 35% gravel.
S	Less than 35% gravel.
?	Requires investigation

Thickness Class

Class	Average Thickness in feet (metres)	Tons per acre (Tonnes per hectare)
1	greater than 20 (> 6)	greater than 50,000 (> 18 500)
2	10-20 (3-6)	25,000-50,000 (9 000-18 500)
3	5-10 (1.5-3)	12,500-25,000 (4 500-9 000)
4	less than 5 (< 1.5)	less than 12,500 (< 4 500)

Geological Type

IC	Undifferentiated Ice-Contact Stratified Drift	OW	Outwash
ICT	Ice-Contact Terrace	LB	Lacustrine Beach
K	Kame	LP	Lacustrine Plain
E	Esker	LD	Lacustrine Delta
FM	End Moraine	AL	Older Alluvium
		WD	Windblown Forms

(see Appendix C for descriptions of Geological Types.)

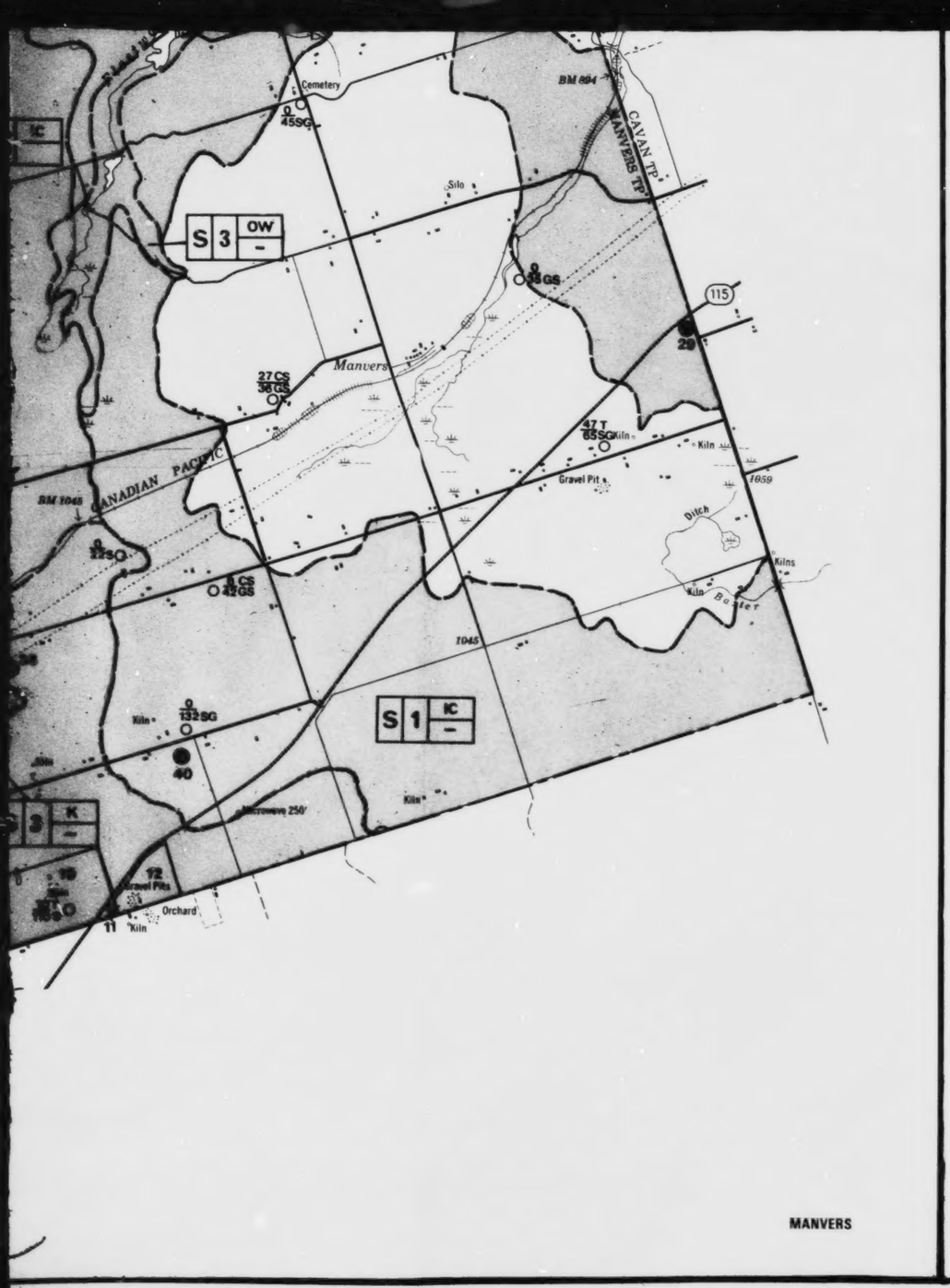
Quality Indicators

	If blank, no known limitations present
C	Clay and/or silt (fines) present in objectionable quantities
L	Deleterious lithologies present
O	Oversize particles or fragments present in objectionable quantities
-	Requires investigation

SOURCES OF INFORMATION

Base map by Surveys and Mapping Branch, Ontario Ministry of Natural Resources.
Licence data from District and Regional Offices, Ontario Ministry of Natural Resources.
Aggregate suitability data from the Engineering Materials Office, Ontario Ministry of Transportation and Communications.
Selected drilling data from the Ontario Ministry of the Environment and the Petroleum Resources Section, Ontario Ministry of Natural

MANVERS



MANVERS

(Note: S-sand, G-gravel, C-clay, T-till)

DEPOSIT SYMBOL

Deposits are identified by gravel content, thickness class, deposit type and quality indicators. Gravel content is expressed as percentage of crushable material. Classes are based on potential aggregate tonnage per acre and are designated numerically. Type refers to geologic origin. Quality modifiers indicate variations in grain size distribution and lithology.

Gravel Content	Thickness Class	Geological Type
		Quality Indicators

Gravel Content

G	Greater than 35% gravel.
S	Less than 35% gravel.
?	Requires investigation

Thickness Class

1	greater than 20 (> 6)	greater than 90,000 (> 27 000)
2	5 to 20 (1.5-6)	12,500 to 90,000 (4 500-27 000)
3	1 to 5 (1.5-3)	12,500 to 90,000 (4 500-9 000)
4	less than 5 (< 1.5)	less than 12,500 (< 4 500)

Geological Type

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Compilation and drafting by C. M. Kwiatkowski

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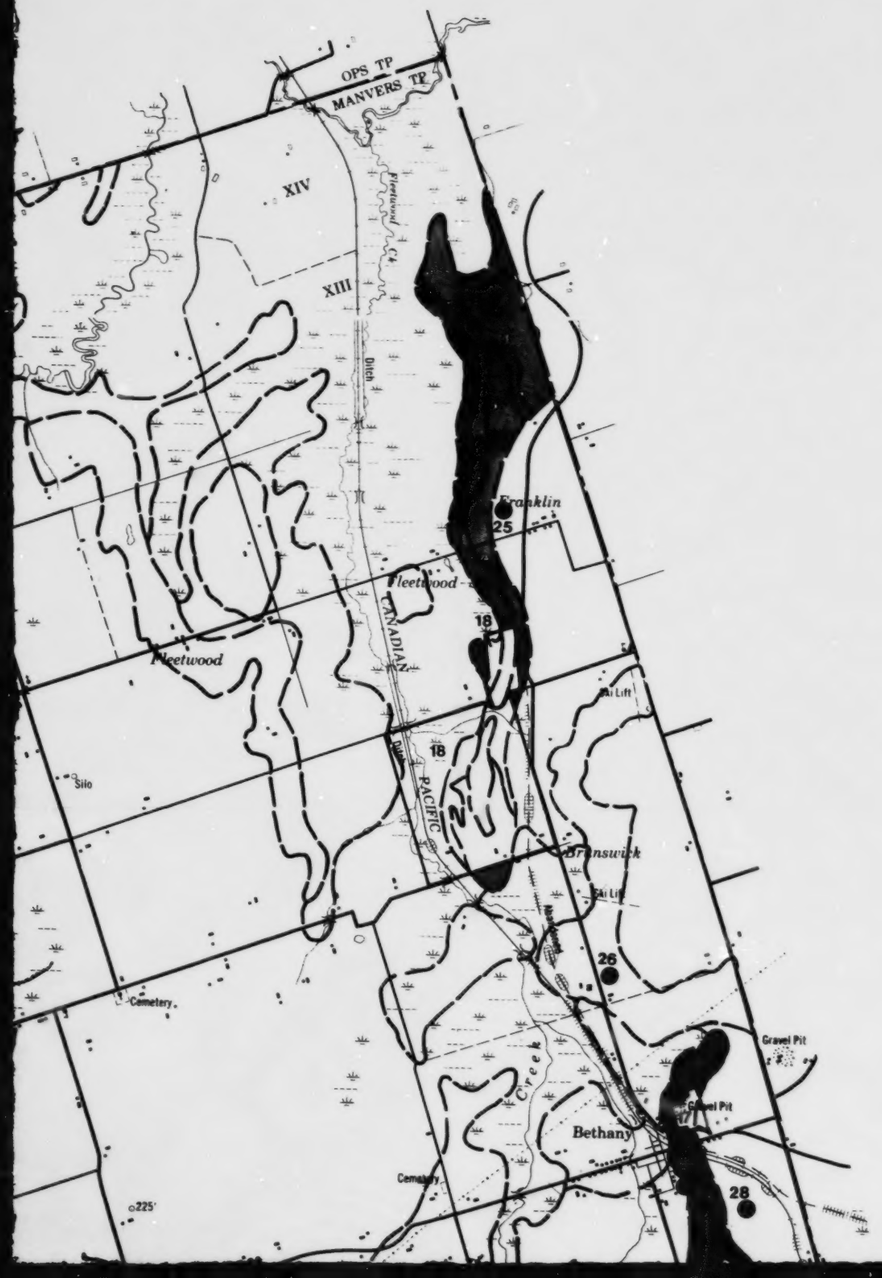
This map is to accompany O.G.S. Aggregate Resources Inventory Paper 7.

OPS TP
MANVERS TP
MOUNT HOREB
XIV
XIII
XII
Fleetwood Creek
Franklin
25
Fleetwood
18
CANADIAN PACIFIC
Ski Lift
Brunswick
26
Gravel Pit
Bethany
28
Janetville
Viewlake
Dam
Silo
Sports Track
Cemetery
Kilns
967
Creek
19
21
22
23
Gravel Pit
Lifford
Silo
225'
41
Janetville
Creek
River



Ontario

Ministry of Natural Resources

Hon. James A.C. Auld
Minister

Dr. J.K. Reynolds
Deputy Minister

ONTARIO GEOLOGICAL SURVEY
AGGREGATE RESOURCES INVENTORY

MANVERS TOWNSHIP
VICTORIA COUNTY

MAP 2
SELECTED SAND AND GRAVEL RESOURCE AREAS

Scale: 1:50,000

Mile 1 0 1 Mile

Metres 1000 0 1 Kilometre

NTS Reference: **31 D/2, 31 D/7**

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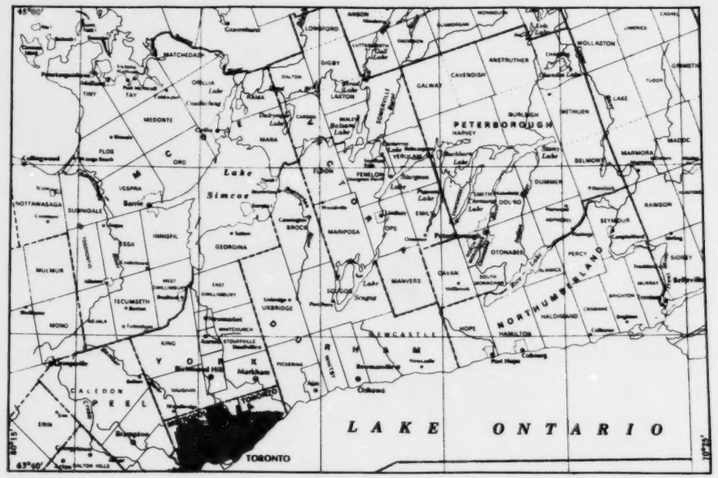
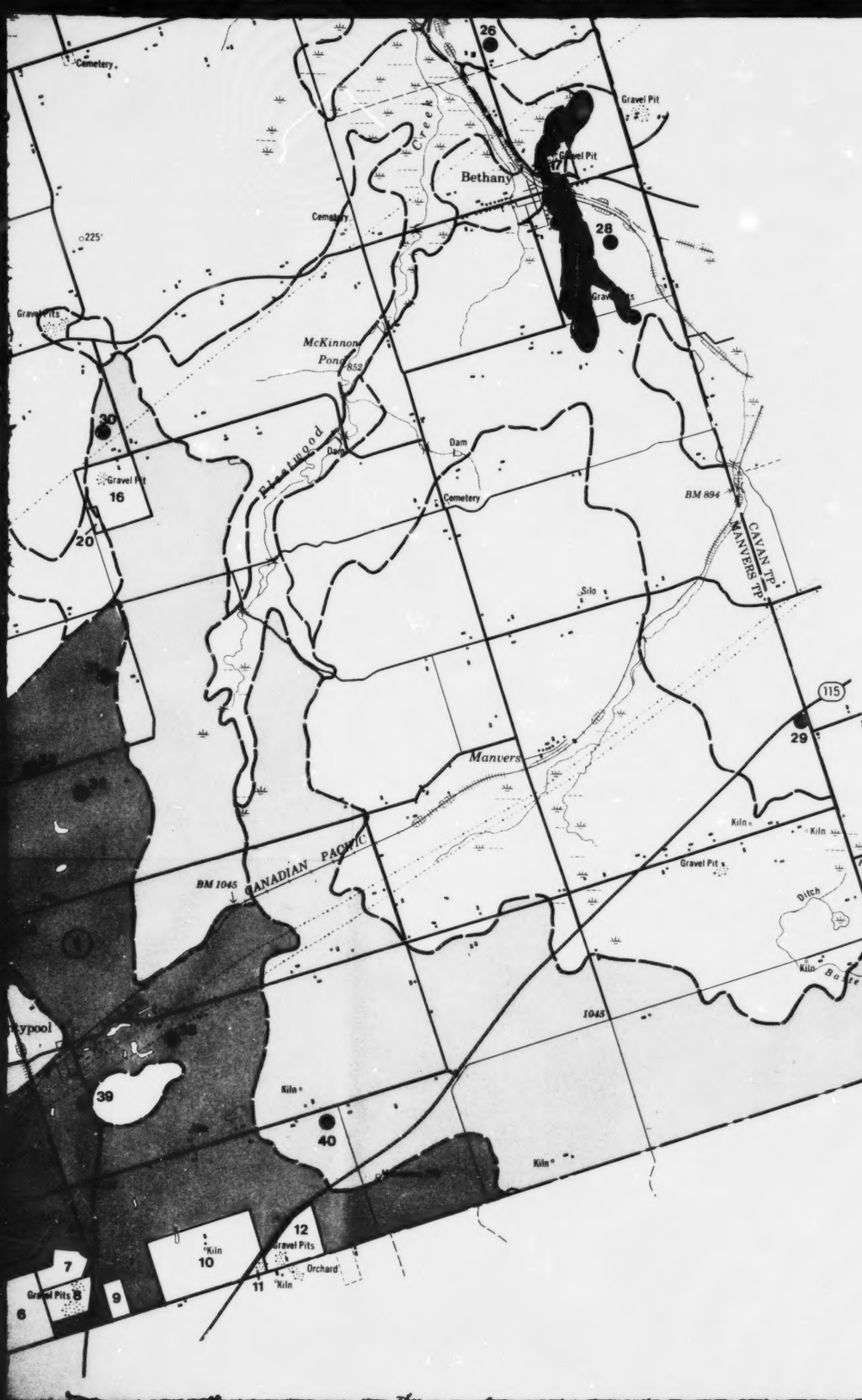


SYMBOLS
(Some symbols may not apply to this map)

Geological and aggregate thickness boundary.

Sports Track
Gravel Pit
21
Gravel Pit
Janetville
Cemetery
22
X
River
Gravel Pit
Lifford
Cemetery
23
Silo
IX
Pigeon
Gravel Pits
Yelverton
VIII
VII
BUNKER HILL
Dam
VI
960
MANVERS TP
1010
2 Lines
Silo
Hallyduff
Gravel Pit
15
Burton
Lotus
V
990
IV
III
37
14
1120
II
Silo
1
Gravel Pits
3
4
5
6
7
Gravel Pits
8
9
10
Kiln
11
Kiln
12
Gravel Pits
Orchard
Kiln
40
39
Portypool
13
Gravel Pit
1
BM 1045
CANADIAN PACIFIC
Manvers
1045
Gravel Pit
Kiln
16
20
30
Gravel Pit
Dam
Dam
Cemetery
Silo
BM 894
McKinnon Pond
852
Cemetery
225
Silo
Cemetery
Bethany
Gravel Pit
17
28
Gravel Pit
26
Creek
Elmwood



SYMBOLS
(Some symbols may not apply to this map)

- Geological and aggregate thickness boundary.
- Selected sand and gravel resource area; Primary significance; Deposit number: see Table 3.
- Selected sand and gravel resource area; Secondary significance.
- Selected sand and gravel resource area; Tertiary significance.
- 2 — Licenced property boundary; Property number: see Table 2.
- 4 — Unlicenced sand or gravel pit; Property number: See Table 2.

SOURCES OF INFORMATION

Base map by Surveys and Mapping Branch, Ontario Ministry of Natural Resources.
Licence data from District and Regional Offices, Ontario Ministry of Natural Resources.
Aggregate suitability data from the Engineering Materials Office, Ontario Ministry of Transportation and Communications.
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BUNKER HILL
MANVERS TP.
Burton
Lctus
Dam
Silo
Gravel Pit
Ballyduff
Manvers
Cemetery
Dam
Gravel Pit
BM 894
BM 1045
CANADIAN PACIFIC
Portypool
Kiln
Orchard
Gravel Pits
New Park
960
990
1010
1045
1120
VII
VI
V
IV
III
II
I
16
20
15
13
37
39
40
14
1
2
3
4
5
6
7
8
9
10
11
12

MANVERS

●4 Unlicenced sand or gravel pit; Property number: See Table 2.

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MANVERS TP
MOUNT HOREB
XIV
XIII
Waterwood Ck
Ditch
Franklin
Fleetwood Sta
CANADIAN PACIFIC
Fleetwood
Ski Lift
Brunswick
Ski Lift
Sports Track
Silo
Dam
Janetville
XII
Viewlake
Kilns
Cemetery
Creek
Gravel Pit
Sports Track
Gravel Pit
Gravel Pit
Lifford
Cemetery
Gravel Pit
Creek
Bethany
Gravel Pit
Cemetery
LINDSAY FORMATION
LINDSAY FORMATION
X
Janetville
Creek
River
895
967
225'
>90
>55
>80
>130
>94
>87
>144
50
35

Ontario

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Deputy Minister

ONTARIO GEOLOGICAL SURVEY
AGGREGATE RESOURCES INVENTORY

MANVERS TOWNSHIP
VICTORIA COUNTY

MAP 3
BEDROCK RESOURCES

Scale: 1:50,000

Mile 1 0 1 Mile
Metres 1000 0 1 Kilometre

NTS Reference: **31 D/2, 31 D/7**

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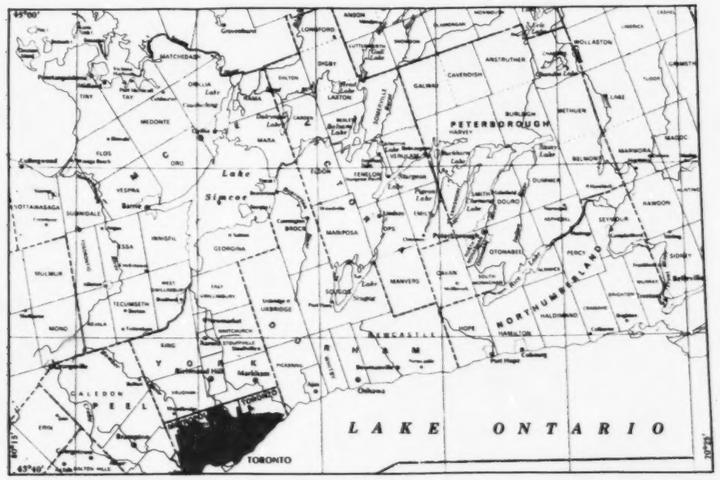
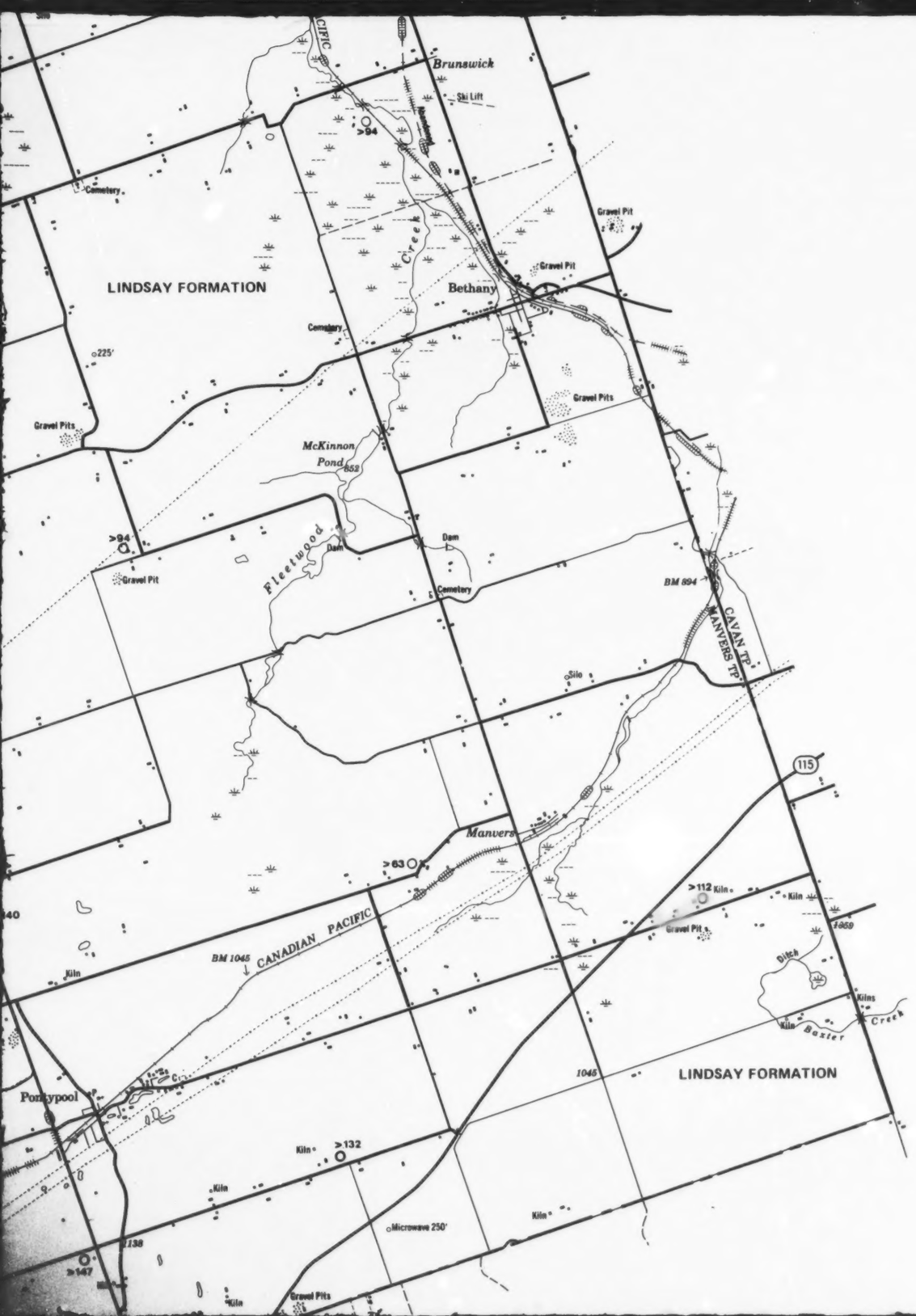


LEGEND

Janetville
Kilns
Cemetery
Creek
967
Sports Track
Gravel Pit
River
Lifford
Silo
Brunswick
Ski Lift
Abandoned
>94
Cemetery
Gravel Pit
Bethany
Janetville
>87
Cemetery
>144
LINDSAY FORMATION
225'
Gravel Pits
McKinnon Pond
852
Yelverton
Pigeon
Fleetwood
Dam
Cemetery
BM 894
BUNKER HILL
960
MANVERS TP
1010
2 Lines
Ballyduff
Burton
>205
Lotus
>140
Manvers
>63
>112
Kiln
990
CANADIAN PACIFIC
BM 1045
Gravel Pit
Pontypool
>120
1045
LINDSAY FORMATION
>132
Kiln
Microwave 250'
1130
1138
>147
I
II
III
IV
V
VI
VII
VIII
IX
X
XI
XII



LEGEND

PALEOZOIC
ORDOVICIAN
MIDDLE ORDOVICIAN
LINDSAY FORMATION
Limestone

SYMBOLS

(Some symbols may not apply to this map.)

- Geological boundary.
- 25 — Drift thickness contour line (25 foot (8 m) interval).
- x — Isolated bedrock outcrop.
- Bedrock within 3 feet (1 m) of surface: see Table 4.
- Bedrock covered by 3 to 25 feet (1 m to 8 m) of overburden: see Table 4.
- Bedrock covered by 25 to 50 feet (8 m to 15 m) of overburden: see Table 4.
- 1 — Selected bedrock resource area; Deposit number: see Table 6.
- Q4 — Licenced quarry boundary; Property number: See Table 5.
- ● Q4 — Unlicenced quarry; Property number; See Table 5.
- ○ 27 — Selected drilling location indicating reported depth to bedrock (in feet).

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BUNKER HILL

MANVERS TP

Burton

Lotus

Ballyduff

Manvers

Pontypool

LINDSAY FORMATION

New Park

CANADIAN PACIFIC

Fleetwood

Gravel Pit

Dam

Cemetery

Silo

Kiln

Microwave 250'

Gravel Pits

Orchard

BM 894

BM 1045

VII

VI

V

IV

III

II

I

960

990

1010

1045

1120

1138

>205

>140

>63

>112

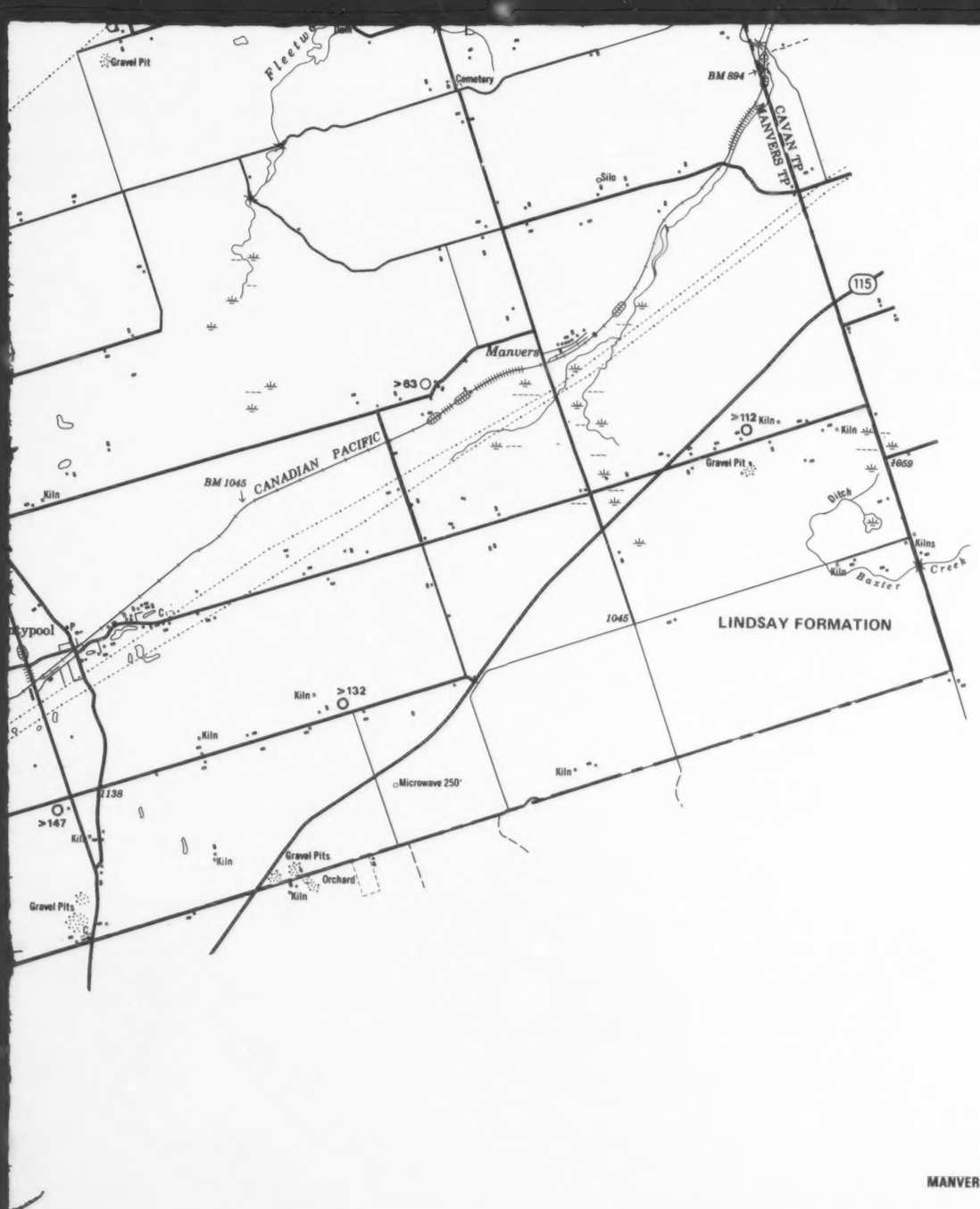
>120

>132

>147

>126

>129



MANVERS

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